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JOINT WORKING GROUP ON ENVIRONMENTAL ATLASES

GROUPE DE TRAVAIL COMBINÉ POUR L'ETUDE DES ATLAS DE L'ENVIRONNEMENT

Examples of Environmental Maps

Exemples de Cartes de l'Environnement

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MAP COLLECTION
UNIVERSITY OF ALBERTA
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CANADA

I. G. U. - I. C. A. Working Group on
ENVIRONMENTAL ATLASES

Examples of Environmental Maps

Groupe de Travail combiné U. G. I. - A. C. I. pour l'étude des
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EXAMPLES OF ENVIRONMENTAL MAPS

EXEMPLES DE CARTES DE L'ENVIRONNEMENT

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EXAMPLES OF ENVIRONMENTAL MAPS

INTRODUCTION

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The Joint Working Group on Environmental Atlases was created in the summer of 1976, on the occasion of the international meetings held in Moscow between the I. G. U. and the I. C. A.

The aim of this working group was to promote collaboration between geographers and cartographers. Both were facing different problems in the preparation of Environmental Atlases - the geographers thinking about the best way of defining and expressing each subject and about the distribution of data within their areas; the cartographers concerned with selecting, arranging and converting these data into adequate graphic representations.

One of the early conclusions of the Working Group was to start the publication of a series of essays on particular maps. These maps were to be selected from atlases that could claim to be "environmental". And each essay was to be accompanied by a colour reproduction of a part of the map in question.

Our purpose is to provide both geographers and cartographers with examples which could serve as guides to the ways in which data might —or indeed might not— be handled in the mapping of similar problems. The essays have not been written with any intention of proposing working rules, merely to try to mitigate the frustration of fruitless attemps. In this way we hope that creative new work can reach a superior level, either by improving on the method used in the example or, perhaps, by choosing an entirely opposite way.

A delicate point is in the definition of "environmental map", for without some limitation and in the absence of convention, we ran the risk of reviewing virtually the whole scope of thematic cartography. At the first meeting of the Group this subject was thoroughly debated until we had reached a conclusion that at least permitted us to continue our task. Our definition was as follows:

"We have understood initially by the 'environment' those geographical circumstances which influence (preserve, ameliorate or degrade) the human ecological system. Atlases of the environment are related to the work of other scientific disciplines and display cartographically the elements in and the complexity of the environment for a region, or country or a group of regions or countries."

There is one group of specialised maps

which holds such a powerful attraction for both scientists and general users that it tends to dominate the study and representation of environment. It is that dealing with aspects of environmental disaster —or "impact studies"— possibly produced by human action. While none would deny the importance of such maps, as a group they may be said to be analogous to environmental pathology; the environmental theme seems to us to be much more general and calls for study of its anatomy and physiology as well.

Obviously some initial enlargement of the theme is possible: the notion of progressive deterioration could be added to that of variation in relation to physical environment. Such 'historical' maps would reflect changes that happened over time rather than present tendencies as inferred from such changes. In this sense we would be entering the field of forecast maps. And there seem two other possible approaches to enlarging the field; one would be to describe in increasing analytical detail aspects of the physical environment which can influence man —this is what has traditionally been done in National and Regional atlases. Another way would be to neglect the physical environment and to study variability in other fields affecting man —cultural, economic, political, social, etc.

What is environmental cartography? A representation of man's physical environment? A representation of the variability of social, etc. factors affecting man? But note that if it were decided that our subject is the representation of everything influencing human life, then all possible topics could claim to be included as environmental.

Another important problem is that of the quantity of existing data about these subjects. Even assuming some limitation to the chosen field, the quantities of data are potentially so vast that working on them would overwhelm present cartographic possibilities even when assisted by the full potential of computer aided cartography.

By way of a first solution one can envisage scale enlargement. Topographic maps could be changed into environmental maps, though not without difficulty as we have seen from the experiences of colleagues working in this way. But an environmental atlas lays claim to giving us instant and wide information via reduced scale maps —but in doing so conventional generalisation is liable to be technically difficult or quite misleading. Furthermore such an atlas would surely be obliged to maintain data both in a perpetual condition of storage and under continual revision? The cartographic use of these data would necessitate special programs of generalisation and visualisation which lie beyond present day manual possibilities. We can increasingly see the field of cartography and that of computer processing drawing nearer to each other, and in some of the present examples we observe just this.

The subject of environment presents wide perspectives for geographers and cartographers: however it has to be said that so far little has been achieved in terms of creating true natural regions from the point of view of environment, either in analysing an isolated element across broad multinational areas or through synthesising studies.

The essays and sample maps we present here are only a first step; the idea of this Working Group is to continue publishing, so that other subjects and methods can successively appear as on-going comentaries on our geographical and cartographic world.

COMPUTER MAP OF CHROMIUM FROM THE REGIONAL GEOCHEMICAL ATLAS OF SHETLAND *

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The atlas, of which this map is an example, has largely been made by computer. A data base of geochemical information was prepared by the Institute of Geological Sciences (I. G. S.); this was in digital form. However the geochemical information meant little —to geochemists or geologists or environmental scientists— until it was mapped. Automated cartography at the Experimental Cartography Unit (E. C. U.) was therefore a natural procedure, and especially so, since both organisations were part of the British Natural Environment Research Council.

Increasingly one finds large data sets of geographical interest that are collected by specialists and that are in digital form; for example censuses of population or of agriculture. And they are in digital form because of the great advantages of flexibility, speed and reliability with which the vast quantities of original data can be interrogated through computers. These same advantages are now becoming available, through developments in automated cartography, to the geographers and cartographers who are concerned with making environmental atlases. The inclusion of this map of a highly specialised subject in these papers about environmental atlases has to seek justification mainly by a brief examination of its preparation: this examination does not attempt a description of automated cartography or of the techniques of geochemistry since both subjects are fully covered elsewhere. It does, however, seem important to commence with some description of the way in which the raw data were collected.

DATA CAPTURE

Sampling methods were used by the Geochemists to collect the data so as to cover very large areas —i. e. the Highlands of Sotland initially— on a rapid time scale —i. e. 5 years— and in sufficient geographical detail for the prime purpose of mineral exploration on a reconnaissance basis —i. e. for mapping at 1:250,000 scale—. The sampling sites were on first and second order streams and each was chosen to characterise the catchment area up-stream of the site. The sites were selected so as to provide a satisfactory compromise between overall regional trends and great local detail. At each site samples of stream sediment were carefully collected.

The locations of the sampling sites were marked in the field on Ordnance Survey 1:50,000 maps; each site was given a serial number. The locations of sites and

* From the series of Regional Geochemical Atlases of Britain (I. G. S. London, 1978...).

their key numbers were subsequently digitised with precision (e. g. in relation to the position of the stream concerned) in E. C. U.; thus the locational data and the analitycal data could be merged together in the computer.

(It is of some interest to note that digitising the site location proved to be a significantly more accurate way of providing locational information than by using written grid references, where human error, such as occasional inversion of northings and eastings, is difficult to detect.)

GEOCHEMICAL ANALYSIS

The next task was to analyse each sample to identify its mineral content. This was done in a Jarrell-Ash direct reading spectograph. This machine provides —in digital form— mineral concentrate values for each element concerned. In the case of the Shetland Islands the 32 elements analysed were as shown below; however not all of these merited mapping because some of them, for example, were virtually absent from Shetland. (Those excluded from the atlas are shown in brackets.)

(Aluminium)	Iron	(Silver)
Barium	(Lanthanum)	(Strontium)
Beryllium	(Lithium)	(Tin)
(Bismuth)	Lead	(Titanium)
Boron	(Magnesium)	Uranium
(Calcium)	Manganese	Uranium in water
Chromium	Molybdenum	
Cobalt	Nickel	Vanadium
Copper	(Potassium)	(Yttrium)
(Gallium)	(Rubidium)	Zinc
(Germanium)	(Silicon)	Zirconium

A variety of control tests were performed on this data base to check the consistency of values and to identify errors: these statistical checks made by the geochemists have been described in the technical literature. They are important as a means of validating the data set, and of giving confidence to the accuracy of values recorded at the sampling sites.

BASE MAP

In order to study geochemical data with much meaning they have both to be mapped and to be seen against the background of suitable base maps. The original intention had been to treat the geochemical data as simple overprints to the existing geological maps of the country (at the scale of $^1/_4$ inch to the mile). Hovewer this was not entirely satisfactory; for example, the locations of the sampling sites which had the accuracy of the 1:50,000 maps, did not always fit with the detailed shapes of rivers, coastlines, etc., on the smaller scale (and manually generalised) geological base maps; many of the streams that had been sampled were also absent from these base maps: consequently the areas of the catchment basins which the sample sites represented could not be deduced. Furthermore the geological interpretation of many parts of Highland Scotland as shown on existing geological maps made many years ago was naturally undergoing a process of revision: this was both in terms of classification and of detailed shapes as mapped. Because the geological background often has a significant bearing on the interpretation of geochemical patterns —some geochemical anomalies can be directly explained by outcrops of particular rocks— it was accepted that new geological map compilations were desirable for the geochemical base maps.

These new geological compilations were prepared by I. G. S. on the Ordnance Survey 1:50,000 topographical maps. Thus ECU was able to digitise and encode both these new geological boundaries and the complete stream patterns from the same source which they had used in order to digitise the sampling sites. There then existed three coherent sets of cartographic data in digital form, geochemistry, geology and elements of the topography —and these were available for fine automatic drawing at virtually any scale—. It should be added that digitising the topography and geology were substantially greater tasks (both longer and more complicated)

than digitising the locations of the geochemical sampling sites. However it was believed that the creation of this geological and topographical base map information in digital form would be an asset for all sorts of other projects in addition to geochemical mapping.

DESIGN

The 3-colour extract (printed here) from the map of Chromium in the Shetland atlas shows the design solution arrived at for each of the separate maps of mineral elements throughout the series of regional geochemical atlases of Britain, currently being published by the Institute of Geological Sciences.

The cartographic design of these maps started from the need to represent geochemical data which often had great quantative variations between sites that were close to each other as plotted at 1:250,000 scale. Experiments with contours, with grid squares and with symbols (bar diagrams, circles, segments, etc.) finally led to the development and use of simple windrose-type symbols in which the length of arm is directly proportional to the quantity of the particular mineral element at a site clearly pin pointed by a small circle. The scale of the arms varies for each mineral element, and so does the direction. These symbols seemed to provide maximum information with minimum overlap, etc., and without blotting out important supplementary information provided by the base map. Although such symbols were initially unfamiliar to geologists there seems, over the last four or five years to have been no problem in geologists and others learning to use them efficiently. It is also important that such symbols can be drawn quickly and accurately by automated systems, either for interrogation or checking on cathode ray tube displays or for drawing as finished reproduction material by high precision flat bed plotters.

It will be seen that these geochemical maps let the data on which they are based show through strongly in the cartographic design; interpretation between data points is left to the eye and mind of the user. Other cartographic methods, e. g. contouring, are concerned with making explicit interpretations between data points and sometimes to the extent of submerging the data points completely. Both approaches have their advocates in traditional as well as in computer cartography. In the case of the geochemical data however there are often major variations in mineral content at sites that occur on the map within a few millimetres of each other: these differences are treated as real and not as noise by the experts. Any contouring or "surface fitting" technique seemed liable to use mean values and, in doing so, to smooth away or hide the sharpness of contrast between adjacent sites.

The topography has been represented on the base maps primarily by the river and stream pattern, the coastline, plus the National Grid and a latitude and longitude graticule. Here the important requirement was to show the complete 1:50,000 stream pattern in its full intricacies at the 1:250,000 scale. This was so as to furinsh a picture of areas (stream catchments) which had in effect been represented by sampling points each of which —by definition— was at the edge of and not in the middle of the area. A high accuracy plotter using a light spot projector made this a quick and elegant operation.

A conscious decision was also made to show the geology in a "mono tint". This was partly based on a need to ensure that geological colour did not overwhelm geochemical values, and partly on a general desirability of restricting printing to three colours. In doing this it was accepted that the geological tints and patterns used on any one atlas might not be consistent for the complete range of geological categories involved over the entire country: thus it is possible that the same tint may be used for different formations as between different atlases. This potential "inconsistency" between atlases seemed

justifiable on two counts; first as a means of maximising the legibility of the geological formations within any one atlas; and second, because the basic source of the information (geological, geochemical and topographical) existed in cartographic data base form in the computer, and thus was open to interrogation, or capable of being reconstituted in any graphic form rapidly and cheaply. In this way it is possible for each map to be an ad hoc solution without perjudicing the overall consistency of the information.

Each atlas is of course made up of a sequence of maps of mineral elements, and each map is accompanied by a short commentary of text and statistics. Each atlas also has general maps of the region for reference at the same scale.

In some cases, a few preliminary edition copies have also been prepared with the geochemical symbols for each mineral element on a separate piece of stable film. Comparisons between elements can tehn be made by overlaying the films. Many users do however find that handling 20 or 30 large pieces of film more or less at the same time presents problems.

PUBLICATION

The prime purpose of the geochemical survey is to help mineral exploration: and it is for that reason that the work has been sponsored by the British Department of Industry. But it is already clear that in addition to organisations concerned to develop mineral resources there are others —e. g. planners— to whom the discovery of new mineral deposits has environmental significance. This would be especially the case for instance if a valuable new mineral deposit was identified in a national park or nature reserve.

The whole project also seems to have aroused a growing interest among agricultural scientists and epidemiologists —as the professional literature demonstrates. The particular map extract of Chromium in Shetland shows a sharp contrast between two islands; this had been recognised by generations of local farmers but not previously explained.

The majority of users of this kind of information seem at present likely to want to consult printed maps such as these within a normal scientific atlas. Increasingly, however, there are those in research organisations and universities who also want to be able to interrogate for themselves the raw data from which the maps are derived, and to do so on displays, line printers, and the like. It is thus important that the information is also available in digital form; and this is the case.

The national data bank represented by the totality of this information is already large and growing larger. The Shetland atlas shows about 1,800 sites, the Argyll atlas (currently in production at the same scale and format) handles roughly 12,000 sites, and more mineral elements are also involved. One of the advantages of using the digital form of the data is that one is free to select whatever particular "window" seems appropriate, and to avoid the restrictions that seem inevitable with sheet lines, scales and even graphics chosen for some more general purpose.

The Shetland atlas was the first to be published; some six or seven other atlases are currently under production and the series will soon cover the whole of Scotland north of the Highland Line. A start was made in the north of the country for various reasons, e. g. the well developed stream pattern which helped with sampling, and the relative absence of polluted water and of waste tips, etc., that might have confused regional geochemical patterns in the early days of the project when knowledge and experience was being accumulated. There is also a simple logic in starting in the north and working south.

Geochemistry apart, it seems certain that many of the environmental maps and atlases of the future will be derived from computer based data. This small map extract shows at least one example of what was possible in the 1970s: exciting new possibilities seem to lie ahead.

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MAP OF THE SYNANTROPIZATION OF THE ENVIRONMENT IN POLAND

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The Institute of Geography and Spatial Organization of the Polish Academy of Sciences has initiated work on the Atlas of Resources Values and Threats to the Natural Environment in Poland. The Atlas is planned to supplement the National Atlas of Poland, an edition of which was published in 1978. The new atlas is planned to contain about 100 tables. The general conception of the atlas was designed by Prof. Stanislaw Leszczycki in 1976. Among the maps presenting the resources, values and threats to individual components of the environment (mineral and rock resources, terrain relief, air, water, vegetation and soils) the design also assumes the inclusion of some general evaluation of natural landscape in terms of its aesthetic value and the degree of its synantropization. This part of the atlas is to cover three full-page maps, the editing of which was undertaken by the present authors. The originals of these maps have been prepared.

The National Atlas of Poland contains two maps: "Types of natural landscape" and "Physico-geographical regions". The authors in their editing of evaluation maps decided to use the basic units of the physico-geographical division of the country at 1:2,000,000 scale: the so called mezoregions (minimal microregional units are not considered in the atlas). The network of units at the mezoregional level of the hierarchy was then assumed as basic entities for the maps of environment evaluation.

Thus the first of the three maps in the section, entitled "Landscapes and physico-geographical units" is a transformation of the two maps referred to above from the National Atlas of Poland. It presents (in colours) 18 types and species of the natural landscape which have been differentiated on two grounds; first on the basis of morpho-genetic and lithological features in those areas which reveal small hipsometric and climatic differences and secondly on the basis of climatic and vegetation differences occurring at different altitudes in mountainous regions. This served as the background for delineating the boundaries of mezoregions, each of which is characterized by specific types or species of landscape. Thence we have obtained 318 regional units, and these have been given five-figure key numbers. These key numbers ase based on the decimal system, adapted (with some modification) for the physico-geographical subdivision of Europe, as accepted by the International Federation of Documenta-

tion (FID) in 1971. The names of the units are given in the margin of the map.

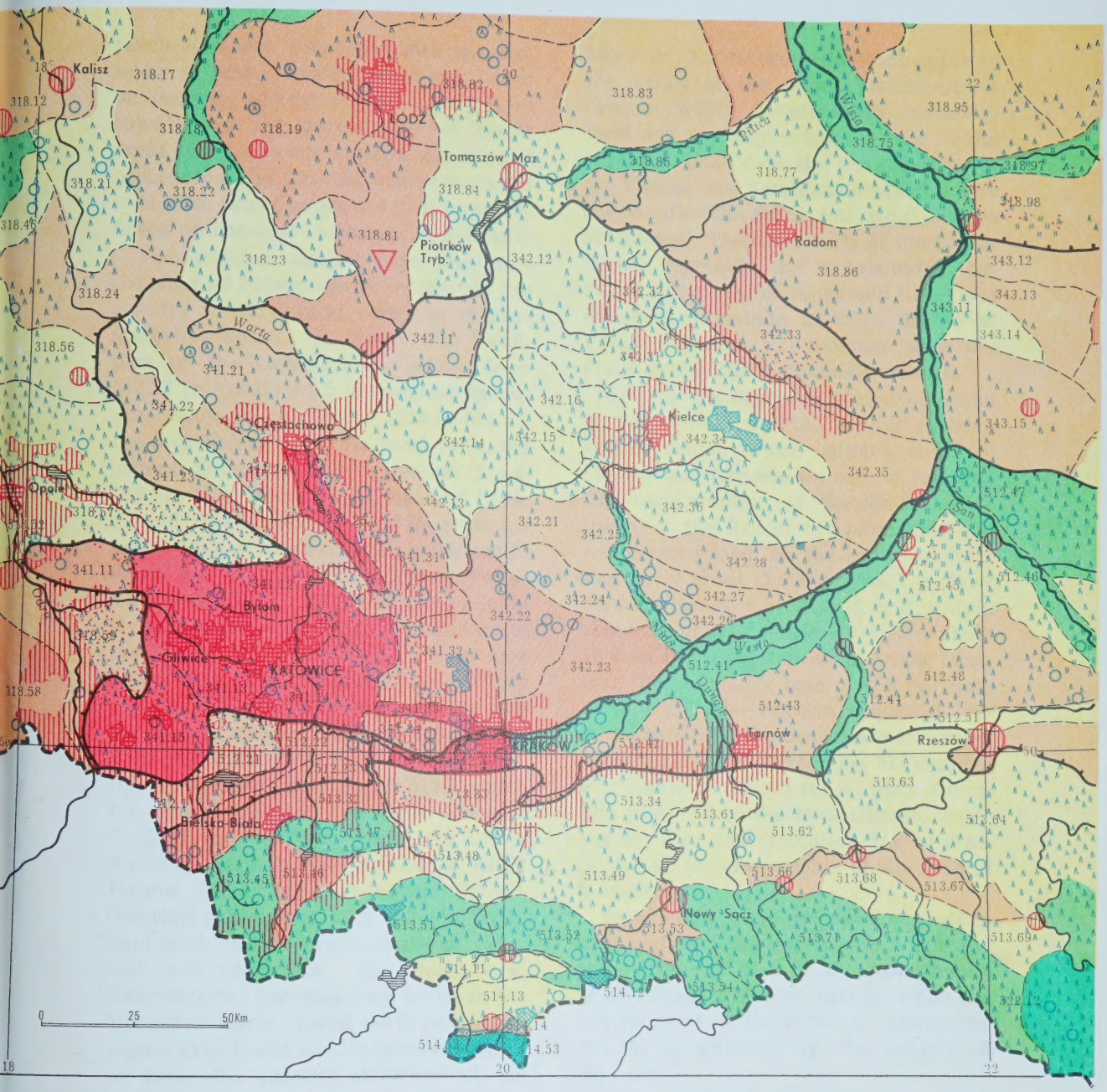
The key numbers or numerical indices express the hierarchical system of physico-geographical division, which, in our five-figure designations, refers to five size levels. In the territory presented on the map we are dealing with two large areas of Europe: first, extra-Alpine (post-palaeozoic) lowland and upland Western Europe, denoted by the first figure "3", and, secondly, the Carpathian area, connected with young (tertiary) fold movements, these are denoted by the first figure "5". The second figures denote physico-geographical provinces, for instance: 31, Central European Lowlands; 34, the Upland of Little Poland; 51, the Western Carpathians together with Northern Sub-Carpathian Region.

The third refers to subprovinces: 318, Lowlands of Central Poland; 314, Silesian-Cracovian Upland; 342, Upland of Central Little Poland; 343, Upland of East Little Poland; 512, North Sub-Carpathian Region; 513, Outer Western Carpathians; 514, Central Western Carpathians; 522, Outer Eastern Carpathians. The fourth figure denotes macroregions —within provinces, and the fifth— mezoregions— within macroregions. The indices allow for the identification of the reference fields. We are of the opinion that as regards problems of environment it is better to use natural units which reveal some degree of homogenity than to employ the more artificial and variable administrative sub-divisions or some incidental geometrical arrangement. The mean size of our reference units is c. 1000 sq · km, with extreme values varying from several hundred to several thousand sq · km.

This first map "Landscapes and physico-geographical units" served as a basis for the next two maps, which evaluate natural environment from the point of view of anthropogenical change and of its attractiveness for tourists. The map is supplemented by a diagram which represents the % occurrence of main types of landscape in the whole territory of Poland.

The map "Aesthetic evaluation of landscape" asseses the attractiveness of the regions, which have been differentiated in the map discussed above. The six-grade scale of evaluation takes account of type of landscape presented in the first map, of relative altitude based on the equivalent map in the National Atlas of Poland, of occurence of lakes, of the existence of National Parks and reservations, and of the percentage of area covered by forests. We have also considered the existing evaluation of the attractiveness of the area in terms of recreation and tourism. Identification of the reference units is possible via the indices discussed above.

Our third map evaluates the degree of the synantropization of environment; and an extract from it is attached to this paper. It has the same cartographic background as the previous maps, but the content has been enriched by two colour markings: violet for the most altered and green for the least altered areas. Thus violet marks the range of urban-industrial agglomerations, larger urban settlements, large mine workings and those forests that are particularly threatened by developing industry and urban centres. Green markings cover the remaining forests, larger complexes of meadows and pastures, National Parks, landscape parks and natural reserves for flora and vegetation. All these elements have been taken from maps in the National Atlas of Poland with similar content. Another cartographic source was the map by Prof. J. B. Falinski (1975) concerned with the degree of synantropization of vegetation in Poland; this uses the same mezoregional units from the National Atlas of Poland. The map was also based on numerous observations gathered by the whole team of botanists and cartographers mapping potential natural vegetation: this was the third element we used to establish a 6-grade scale for the evaluation of the degree of synantropization of mezoregions. Evaluation of each unit is thus the result of the amount of change to surfaces occuring in it and the degree of synantropization of the vegetation, i. e. the result of the disappearance of some species and the appea-



DEGREE OF ENVIRONMENT SYNANTROPIZATION IN CENTRAL PART OF SOUTHERN POLAND

Degree of synantropization by physico-geographical mezoregions

- the lowest
- low
- middle
- high
- very high
- the highest
- boundaries of mezoregions
- boundaries of lowlands, highlands and mountainous areas
- 341.32 decimal designations of mezoregions

- urban-industrial agglomerations and their urban centres

larger urban settlements without the agglomerations

- over 100 thous. inhabitants
- 50—100 thous. ,,
- 20— 50 thous. ,,
- large pits of mine origin
- forests strongly threatened by devastation due to developing industry and urban centres
- other forests
- larger areas of meadows and pastures
- National Parks
- landscape parks
- reservations of flora and vegetation

rance of others, connected with the economy of man. Evaluation is also based on personal observation. Apart from calculationg the percentages of forest areas, we have not applied any formal procedures, and thus the evaluation scale is to some extent subjective; it is however, based on concrete cartographic evidence.

The selected sample from the map covering all Poland shows the part of the country which is most varied as regards synantropization. It covers the Polish part of the Carpathians (indices from 513.32 to 522.12) with the highest mountain range of the Tatra (514.52-514.53) the only Polish alpine National Park, the tectonic Sub-carpathian Depression (514.4-512.51), the structurally Upland of Little Poland (341.11-343.15), with its great urban-industrial agglomeration in the southwest, and a part of the Central Polish Lowlands (318.12-318.98) of predominantly agricultural character. In addition to the Tatra National Park, whose area amounts to 22 074 hectares, the territory covered by the sample section of the map contains 3 smaller National Parks: the Babia Góra National Park in the Carpathians (1707 ha; mezoregion 513.51) with the highest peak in the Outer Western Carpathians - 1725 m high; the Ojców National Park in the Upland of Little Poland (1675 ha; mezoregion 541.42), covering a fragment of a calcium tableland with varied rock formations, caves and rich vegetation. The third park, Swietokrzyski National Park is also in the Upland of Little Poland (6043 ha; mezoregion 342.34) and has fir forests growing on indurated quarzite elevations of the low Swietokrzyskie Mountains (extreme height 612 m).

The lowest degree of synantropizaiotn was given to the region covering the Tatra National Park and to the fragment of forest territories of the East Carpathians in the south-east corner of the map. A low degree of synantropization is also found in the wooded, medium-mountainous ranges of the Outer Western Carpathians (Beskides) and in flood plains and meadow valleys of the bigger rivers. Morever, this category does not apply to the valley of the upper Vistula up to Cracow, which is intensively industrialized and partially urbanized, nor to the region situated over the left tributary of the Vistula - the Kamienna (342.33), where the so called Old Polish Industrial District is situated. The outer parts of the Carpathians, especially the mid-mountain basins, are densely inhabited and have been assigned a medium or high degree of synantropization, in common with the major part of the remaining territories.

The highest degree of synantropization is represented by the Upper Silesian agglomeration, which adjoins those of Cracow and Czstochowa on the east and the agglomeration of Bielsko-Biala, situated at the foot of the mountains and less concentrated, on the south. Jointly they cover about 12 000 sq · km, i. e. about 3,8 % of the area of Poland, and contain about 5,5 million people (1978), i. e. about 16 % of the population of the whole country. The economic base of the intensely urbanized Upper Silesian Industrial District (main town Katowice) is coal mining. Exploitation of coal resources has resulted in changes to terrain relief (mine dumps and pits) and to the local climate, water regime, soils and vegetation, i. e. to practically all the components of the natural landscape.

In addition, there are developments in zinc and lead mining, in the north and the north-east part of the macroregion of the Silesian Upland (341.1), while the environment of Czstochowa (mezoregion 341.25) is affected by the output of iron ore.

In the lowland part of the country a very high degree of synantropization is revealed on the territory of the Lódz urban-industrial agglomeration: this includes Lódz the second biggest town of Poland and the great centre of the textile industry, which, together with its satellite towns, has a population of about 1 mln (mezoregions 318.19 and 318.22). In addition and to the south (in the unit 318.81) is the new centre of brown coal open-cast mining around Belchatów. There, as a

result of making a 200 m deep pit, the pattern of subterranean waters has been disturbed; this will be followed by further natural consequences. Furthermore, the two biggest thermal power plants in the country are being built there, and will be a serious source of air pollution.

A high degree of synantropization was also given to the densely inhabited agricultural regions, especially in the areas covered by loess (342.22, 342.23, 342.55, 343.12, 343.15) where soil erosion caused by agriculture brings about a gradual degradation of the terrain.

SOURCES

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THE ENVIRONMENTAL SITUATION OF THE HALLE-LEIPZIG REGION DETAIL FROM A MAP 1:500,000

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Environmental maps contain very few elements, sometimes only a single one, characterizing a particular phenomenon of the environment. For example, such maps show the distribution of foreign substances of toxic character, like chromium, mercury, or sulphur dioxide, each on separate maps. But of no lesser importance than maps of this kind are those which call the viewer's attention to a complex of elements that can be related to each other. The map explained below is such a complex type of environmental map showing not so much the individual effects but rather the components of a system of effects.

1. SOURCE MATERIAL

The map sample is a detailed example of how it is possible to compile one map showing a complex environmental situation by means of maps from the national atlas of the GDR. The national atlas maps can be regarded as providing a general representation of the raw data. As in this case the following maps from the GDR Atlas were used as basic material:

Number	TITLE OF MAPS/AUTHORS	Scale
2	*Landforms and actual morphogenetic processes* Author: Hans Kugler a. O.	1:750,000
9.1	*Climatic regions* Authors: Wolfgang Böer, Gerhard Schmidt	1:1,000,000
11	*Hydrological survey* Authors: Ludwig Bauer, Rüdiger Spengler, Heinz Schubert	1:750,000
15	*Land use related to natural regions* Author: Hans Richter a. O.	1:750,000
16.1	*Nature reserves* Author: Ludwig Bauer	1:1,000,000
16.2	*Landscape preservation areas* Author: Ludwig Bauer	1:1,000,000
17	*Types of natural regions* Authors: Heiner Barsch, Hans Richter	1:750,000

Number	TITLE OF MAPS/AUTHORS	Scale
23	*Chemical industry, power production and their basis in the mining industry* Authors: Horst Kohl, Hans Rumpf, Heinz Spitzer	1:750,000
24.1	*Potassium and rock salt industry* Author: Horst Kohl	1:1,500,000
24.2	*Chemical fertilizer industry* Author: Gottfried Suchy	1:1,500,000
24.3	*Sulphuric acid industry* Author: Werner Schirm	1:1,500,000
24.4	*Oil, plastics and man-made fibres industry* Author: Werner Gringmuth	1:1,500,000
30.1	*Textile industry* Author: Ernst Benedict	1:1,000,000
32.1	*Woodworking and papermaking industry* Author: Marianne Stams	1:1,000,000
32.2	*Food and table luxuries industry* Authors: Christian Clauß, Erhard John	1:1,000,000
47	*Facilities for recreation and tourism* Authors: Heinz Müller, Stefan Noack	1:750,000

Note that these maps have already been published (1977; partly 1979).

In particular the environmental map example is based on:

a) *Basic map:* river system used as a means of topographic orientation as in the maps of the GDR Atlas.

b) *Source materials* for the elements of the contents:

— Settlement areas were taken from map No 15 of the GDR Atlas, and are represented true to scale.
Basis of map No 15: "Ueber sichtskarte der DDR (General map of the GDR) 1:200,000"; settlement fringes are based on special settlement studies.

— Main types of land use and qualities of natural regions were taken from maps No 15 and 17 of the GDR Atlas.
Basis of maps No 15 and 17: "Uebersichtskarte der DDR 1:200,000"; results of field study of the natural regions of the GDR carried out by a large number of geographers, published in different scales from 1:10.000 to 1:200,000.

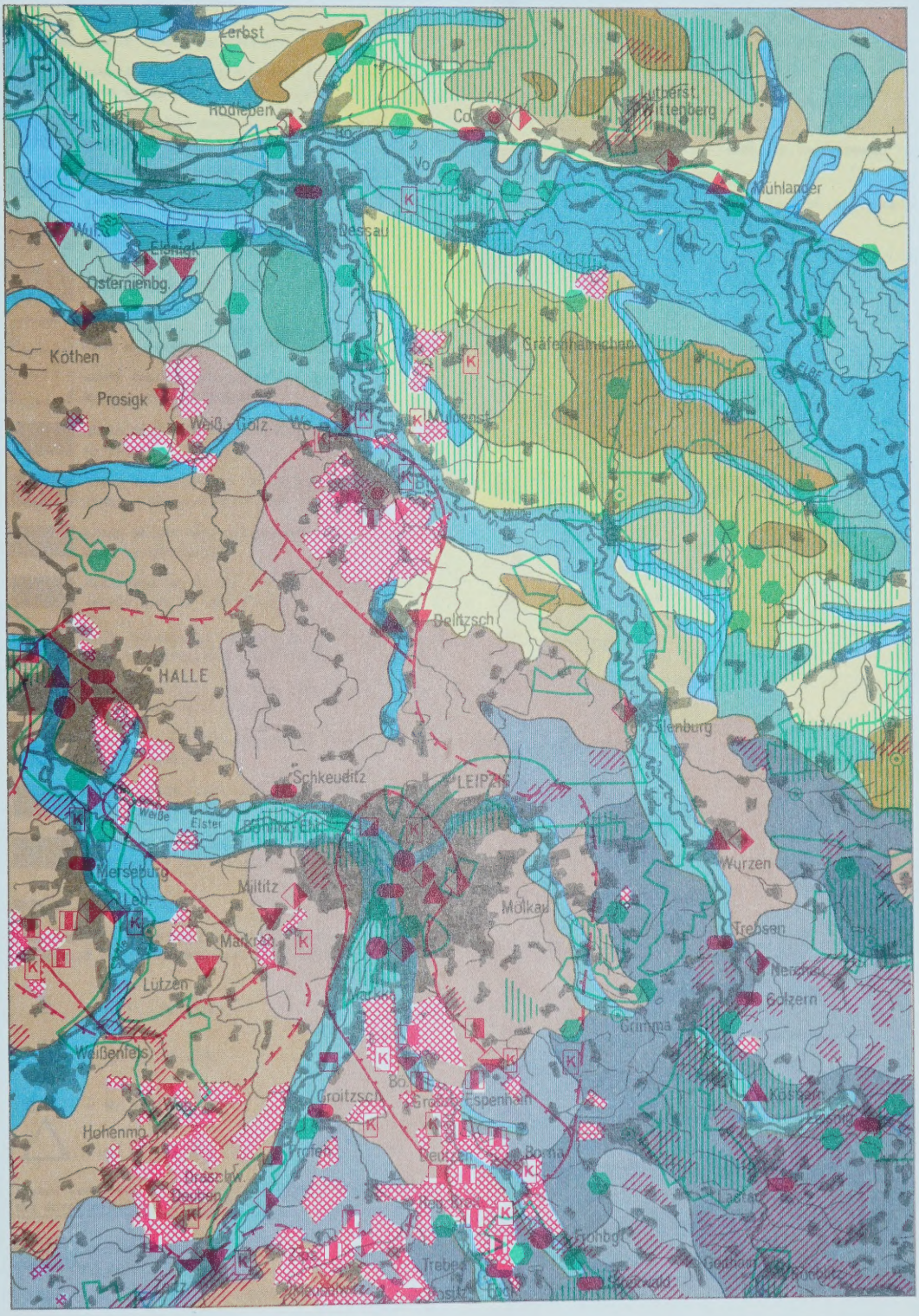
— Areas influenced by mining (opencast mines, filled-up areas) were taken from map No 15 of the GDR Atlas.
Basis of map No 15: "Uebersichtskarte der DDR 1:200,000"; litterature published in different places, among others BARTHEL, H. Braunkohlenbergbau und Landschaftsdynamik (Brown-coal mining and landscape dynamics), Gotha 1963; landscape-ecological studies.

— Landscape preservation areas and nature reserves were taken from maps No 16.1 and 16.2 of the GDR Atlas.
Basis of maps No 16.1 and 16.2: Handbuch der Naturschutzgebiete der DDR (Handbook of protected areas of the GDR), 5 volumes, 1972-74; records of the Institute of Landscape Research and Nature Protection of the Academy of Agricultural Sciences of the GDR.

The environmental situation of the Halle-Leipzig-Region

Cut-out

Scale 1:500 000



Compiled by E.Benedict, K.Grosser, U.Hengelhaupt

(Academy of Sciences of the GDR, Institute of Geography and Geoecology)

exclusive on the base of maps of the ATLAS DDR

Legend of the map: The environmental situation of the Leipzig-Halle-Region, 1 : 500 000

Land use related to natural regions

- ground moraine region, undulating with knobs, mainly used by agriculture
- ground moraine region, undulating with knobs, used by agriculture and forestry
- ground moraine region, undulating with knobs, mainly used by forestry
- ground moraine region, influenced by perched ground water and ground water, used by agriculture and forestry
- sandy region (dry), used by agriculture and forestry
- sandy region (dry), mainly used by forestry
- sandy region, influenced by ground water, used by agriculture and forestry
- sandy region, influenced by ground water, mainly used by forestry
- hilly region in loose material, mainly used by forestry
- loess region on the lee side of low mountain range, used exclusively by agriculture
- plain in the more rainy loess region, mainly used by agriculture
- hilly country in the more rainy loess region, mainly used by agriculture
- hilly country in the more rainy loess region, used by agriculture and forestry
- hilly country in the more rainy loess region, mainly used by forestry
- valley bottom with meadow-loam cover, mainly used by agriculture
- valley bottom with meadow-loam cover, used by agriculture and forestry
- peaty and waterlogged lowland, used by agriculture and forestry

Rate of low-water flow

mean run-off of the month with the third poorest run-off = index of the low-water flow representative of use

- < 10 m^3/s
- 10 to 50 m^3/s
- > 50 to 100 m^3/s
- >100 to 200 m^3/s

Places and areas with special requirements on quality of the environment (protected areas)

- recreation area
- spa and recreation place
- landscape preservation area
- nature reserve

Areas influenced by settlements

- built-up area
- peripheral zone of a settlement

Influence of soil and relief

- high disposition sheet-wash and displacement of soil
- high disposition to fluvial erosion on slopes and displacement of soil
- daylight mining and dumps

Air pollution

- severe air pollution
- moderate air pollution

Locations of industry with special influence on the environment

Chemical production

- basis chemicals (including fertilizers, except sulphuric acid)
- sulphuric acid
- man-made fibres
- oil and tar products

Thermal power stations

- K — using lignite
- E — using oil/natural gas
- A — using nuclear power

Processing of lignite

- gas and coking plant (using lignite)
- lignite low-temperature carbonizing plant
- lignite briquette plant
- gas and coking plant using other raw materials

Other productions with influence on the environment

- spinning and yarn dressing
- preparation of vegetable and animal raw materials
- production of chemical wood pulp and paper
- sugar beet processing

— Spas and recreation places, recreation areas were taken from maps No 9.1 and 47 of the GDR Atlas.

  Basis of maps No 9.1 and 47: Baederbuch der DDR (Handbook of Spas of the GDR); holiday service of the Free German Trade Union; bioclimatic data of the Meteorological Service of the GDR; studies of the College of Transport "Paul List" in Dresden; various tourist literature.

— Areas with a tendency to soil erosion were taken from map No 2 of the GDR Atlas.

  Basis of map No 2: Field work of a large number of geomorphologists of the GDR.

— Air pollution data were taken from map No 9.1 of the GDR Atlas.

  Basis of map No 9.1: Interpretation of data published by the Meteorological Service of the GDR.

— Low-water discharge of superficial waters was taken from map No 11 of the GDR Atlas.

  Basis of map No 11: List of water gauges of the GDR, Gewaesserkundliches Jahrbuch der DDR (Hydrological Yearbook of the GDR); records of institutions of water supply.

— Locations of industry with particular impact on the environment were taken from maps No 23, 24.1, 24.2, 24.3, 24.4, 30.1, 32.1 and 32.2 of the GDR Atlas.

  Basis of maps No 23, 24.1, 24.2, 24.3, 24.4, 30.1, 32.1 and 32.2: Statistical publications of the Central Administration of Statistics of the GDR; geographical studies of industry.

2. TREATMENT OF DATA FOR THE COMPILATION OF THE MAP

The general map of the environmental situation described here has been based on details from maps in the GDR Atlas. These maps were compiled on the basis of special investigations and several years of field work. Thus, in many cases the maps are based on new scientific findings from several years of new research work, and partly on treatment of existing material. The compilation of those maps of the GDR Atlas which were used for the map of the "Environmental situation" involved 46 specialists, and was the joint work of geographers and cartographers. In order to ascertain the main types of land use and the qualities of natural regions calculations of something called the "coefficient of contingency" were taken as a basis.

3. MAP DESIGN

After discussion with the specialists responsible for the subject matter, the map was designed to avoid subjectivity as far as possible. Great importance was attached to the legibility of the map, both of the individual elements and of their integration into a general impression. In view of the wealth of data and the complexity of the map elements the objective is an ambitious one.

4. MAP SAMPLE

The map sample shown is part of a planned map series for which a limited distribution is planned.

ACKNOWLEDGEMENTS

We would like to thank Prof. Dr. Haase, head of the Section of Geography of the Institute of Geography and Geoecology of the Academy of Sciences of the GDR, for his valuable support, and Dipl-Geogr Breitfeld and Dipl-Ing Grosser, cartographers, of the Department of Thematical Mapping of the same institute for their cooperation.

MAPPING SUSPENDED SEDIMENT CONCENTRATION IN CANADIAN RIVERS

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Canada is a very large country and her water resources are among the most extensive in the world. The maximum use of these resources is essential for the development of the country and leads to a growing demand for more complete and accurate information on hydrological and geomorphological processes in streams and watersheds. This paper is concerned with the cartographical treatment of one of the results of these processes, that of suspended sediment in rivers and streams. It traces the reasons for measuring suspended sediment and the problems which arise so as to give some indication of the reliability of the data. This is followed by a discussion of the reasons for mapping sediment load measurement and the limitations of the map "Suspended Sediment Concentration" which appeared in *Hydrological Atlas of Canada.*

Erosion by water can cause soil losses from cultivated farmlands. Denudation processes stimulated by moving sediment in rivers can lead to the formation of meanders and sandbars, change river channels, interrupt navigation and adversely affect activities along the water courses. Deposited sediment creates many problems, the most serious being the reduction in storage capacities of lakes, changes in the regimes of rivers and the silting of irrigation canals and ditches.

As the editors of the *Hydrological Atlas of Canada* point out "every year, about 300 million metric tons of sediment are carried by Canadian rivers to the oceans or across national boundaries. To appreciate the volumes involved consider that if the suspended sediment reaching the mouth of the Fraser River, British Columbia over a period of 1 year could be massed in a conical pile with 45-degree slopes, it would reach a height equivalent to a 100-story building (almost 300 metres)".

Transportation of soil particles from the land surface begins with the action of precipitation which dislodges soil particles. The subsequent direction of movement of the soil particles depends on the prevailing winds, the land slope and the nature of the vegetation. If overland flow occurs, soil particles may also be loosened by the flowing water and carried toward stream channels. Once the sediment load has reached a channel the largest fraction of the load moved by the river does not spend any time on the bottom of the channel because of stream turbulence. It is carried in suspension. Besides these processes of soil break-up and transportation, other significant contributions are

* I am grateful for the comments and advice of Professor R. W. Packer, University of Western Ontario, in the preparation of this paper and to the federal Ministry of the Environment for the map reproduction materials.

made by mechanisms such as shoreline erosion, wind, and glacial action.

Thus basic sediment data is a vital component in the information required for water resource development. To meet the demand for such data a comprehensive sediment survey program was established, with special emphasis on the alluvial regions of the country.

THE SEDIMENT SURVEY PROGRAM

The first investigations of sediment transported by streams in Canada were undertaken by individual organizations or agencies in 1947 and they were gradually expanded to meet the urgent needs of federal and provincial construction agencies for the assessment of particular projects. Thus the International Columbia River Engineering Board carried out a sediment survey program on the Kootenay River during the period 1947 to 1949. A sediment survey program, begun on the South Saskatchewan River in 1948 by the Prairie Farm Rehabilitation Administration, was later extended to the North Saskatchewan, Saskatchewan and Red Rivers. The Water Rights Branch of the British Columbia Department of Lands, Forests, and Water Resources undertook a sediment survey program on the Fraser River upstream from Hope, in 1950. Thirteen hydrometric cross-sections were included in the program, with the continuous mean monthly suspended sediment yield being determined for several cross-sections for the years 1950, 1951 and 1952.

In addition to these programs, individual samplings and limited souding programs to determine sediment deposition in lakes and rivers were undertaken by various agencies in parts of eastern Canada.

All these programs, too short and limited in scope, included only measurements of suspended sediment; the bed in the river channel was never measured. The methods used for these early surveys were approximate and were limited by the equipment available; with advances in equipment design, however, improved methods have been developed and the results of today's surveys are definitely superior.

In 1961 a continuous sediment survey program was initiated by the federal government but limitations on funds, equipment and personnel at that time restricted the scope of the program to a few stations on prairie streams. At these stations, only suspended sediment was sampled. As time went on, however, the number of stations was increased, taking in streams in other provinces. By 1973 the federal government was operating 160 sediment stations and the government of Quebec an additional 28.

The sediment survey program has the following objectives:

1. Collection and publication of long-term basic sediment records on streams throughout Canada to provide data for:

   (a) Design and operation of reservoirs.
   (b) Design of canals, diversion works and drainage ditches.
   (c) Prediction, evaluation and control of deposition in natural channels.
   (d) Evaluation of erosion control measures.
   (e) Design of treatment facilities for water supply.
   (f) Improvement of fish habitat.

In addition to data collection, the sediment survey program includes special studies in the following fields: sediment surveys of reservoirs and lakes, surveys of rivers for degradation or aggradation processes (for example, the South Saskatchewan River below the Gardiner Dam), deformation of river channels and formation of deltas, morphological studies of watersheds, and different methods of carrying out bed load measurements, etc. The program was at first supervised and partially operated from the headquarters in Ottawa but as it became larger, more of the field work and responsibilities were transferred to district personnel at

Vancouver, Calgary, Regina, Winnipeg, Guelph (Ontario), Montreal and Halifax. However, publication of the sediment data as well as the other study reports is still the responsibility of the Sediment Survey Section in Ottawa.

Sedimentation includes the following main processes: erosion, transportation, deposition and compaction. At present the survey program covers mainly the measurement of transported sediment and, to a minor extent, the measurement and study of deposited sediment in river channels, lakes and reservoirs. The work falls into four principal areas of responsibility:

1) Field work — involving hydrometric operations, sediment sampling or measurement, survey of deposited sediment, etc.
2) Laboratory work — involving the analysis of sediment samples to determine suspended sediment concentration and sediment particle-size distribution.
3) Office work — involving computation, compilation and preparation of data for publication.
4) Examination and analysis of sediment data, geomorphological investigations and studies.

The sediment survey program is conducted in cross-sections of rivers selected specifically for the sediment survey or for the hydrometric survey. Certain of these cross-sections are located at traffic bridges while others are equipped with cableways, catamaran installations or automatic pump samplers.

MEASUREMENT OF SUSPENDED SEDIMENT CONCENTRATION

One of the most important elements in any detailed study of suspended sediment is an accurate knowledge of the flow in the stream (often referred to as the discharge) at the point where the sediment sample is taken. To be of value, each individual suspended sediment measurement must be accompanied by a simultaneous measurement of streamflow which is usually calculated as the product of the velocity of flow and the cross-sectional area of the stream at a particular point.

The suspended sediment concentration is calculated as the ratio of annual suspended load to annual stream flow which thus describes the concentration as a weight of sediment per unit volume of water-sediment mixture. It is expressed in milligrams per litre (mg/l), units which are equivalent to the expression "parts per million" (ppm) commonly used to denote concentration.

The accuracy of the sediment survey records are dependent upon the accuracy of the streamflow records. In general, however, there are many factors besides those related to streamflow which determine the accuracy of the sediment survey records. Some of the more important of these are:

(a) regime of the river;
(b) accuracy and frequency of "individual" sediment sampling;
(c) accuracy and frequency of suspended sediment discharge measurements:
(d) accuracy, frequency and methods of bed load measurements;
(e) accuracy and frequency of bed material samplings;
(f) relationship between the average suspended sediment concentration in the cross-section and the concentration of "individual" samples;
(g) accuracy of laboratory work;
(h) selected methods of computation of the suspended sediment discharge or the total sediment load.

It should be kept in mind that there is little reason to expect a simple relation between runoff and sediment yield. Discharge may be caused by melting snow, moderate rain, or intense rain, and each produces a different sediment load. Also, because of different soils and bedrock types in a watershed, some parts of the basin may be richer sediment sources than others.

In general, data collected during open-water periods are more reliable than

those collected during periods of ice conditions or those obtained by estimation. In southern Ontario at least, half of the annual load occurs during the months of March and April and sample loads collected during periods of low flow are not indicative of the annual suspended sediment load (Dickinson, 1975). Further, water level data collected utilizing a water-stage recorder are more reliable and accurate than those using a manual gauge only, especially for small or flashy streams.

MAPPING SUSPENDED SEDIMENT CONCENTRATION

It is clear that the measured data is instantaneous and discontinuous, characteristics which do not normally lend themselves to map display. Nonetheless efforts were made to extend the data across watersheds. Because sediment concentration fluctuates from year to year, a ten-year average (1961-1970) concentration was used although there were a few places where shorter periods were unavoidable. But in view of the shortage of recorded sediment survey information an effort was made to estimate, to reconstruct or to compute new (additional) sediment data for additional years, additional watersheds and new locations. The methods of estimation have been described by Stichling (1973) who cautions that because of the limited data available the methods of estimation had many shortcomings and weaknesses. For individual watersheds the sediment concentration was adjusted to reflect the suspended sediment concentrations existing before newly built waterworks, reservoirs, diversions, etc., were created.

The sediment data were examined first, then they were related to drainage basin and stream runoff distribution between watersheds. The sediment concentrations for the drainage areas between sediment stations in a single watershed were computed (with adjustments where necessary) from the recorded concentrations at these stations. Finally the average sediment concentration was plotted at the centre of gravity of the respective areas of the drainage basins. The results showed that more than half the land surface of Canada has a mean annual suspended sediment concentration of less than 50 mg/l. It is only in the Prairie Provinces, in an area surrounding Williston Lake in British Columbia, and in a very small area in the Mackenzie River delta that the mean annual concentration is greater than 700 mg/l. The largest mean annual concentration measured, a little more than 2000 mg/l, was on South Tobacco Creek, about 100 kilometres southwest of Winnipeg, Manitoba. The drainage area, however, is less than 95 square kilometres, an anomaly which would not show up on a small scale map of Canada. The high sediment yields of the Mackenzie, Athabasca, Slave, and Liard Rivers are examples of naturally high suspended-sediment loads.

The geographical distribution of these variations in the average sediment concentration had to be taken into consideration when categorising the values for mapping purposes. A variable scale was the obvious solution and the average sediment concentrations were grouped by drainage basins into six categories with the values 0-50, 51-200, 201-400, 401-700, 701-1000 and more than 1000 mg/l.

The first published map showing the distribution of the suspended sediment concentration for Canadian rivers 1972 appeared in 1974. It used the six categories described above, each of them being assigned a distinct colour. The boundaries between major drainage basins were indicated by solid black lines. Because it was difficult to determine the boundaries of the concentration zones on large watersheds, and also on the smaller watersheds where the information on individual and miscellaneous sampling programs or observations were used, boundaries between such zones were estimated and were shown by means of dashed lines. Some additional methods of interpolation for

the adjustment of the boundaries of zones inside watersheds were also made. In some cases the stream runoff distribution between the watersheds was used. Glacier sediment was included as part of stream sediment. The significance of this varies from the glaciers in the Rocky Mountains in the southwest to those of Baffin and Devon Islands in the arctic where they dominate the hydrologic regime.

This map was published at a scale of 1:6,336,000 and it terminated at approximately 75° N. The same information was shown on Sheet 26, with the same title, of *Hydrological Atlas of Canada* published by the federal department of Fisheries and Environment in 1978. For the atlas however the scale was reduced to 1:10,000,000 and the area covered extended northwards to include the total land area of Canada. However no account was taken of the glacier sediments in this northern extension where some of the glaciers are even larger than those of which account was taken on the earlier map.

The atlas map also includes what are labelled as histograms (bar graphs) for selected stations. The are really bar graphs as they do not show frequency but indicate the mean monthly suspended sediment load, expressed in metric tons per day per square kilometre. The bars are plotted on a logarithmic scale so that the relatively small loads in the winter months in parts of Canada are evident. They represent mean monthly values to the end of 1973 and provide a visual impression of the distribution of sediment throughout the year.

THE SIGNIFICANCE OF THE MAP

The map was prepared giving more weight to the large and medium sized watersheds and it should be considered only for these types of watersheds. Indeed on the published scale of 1:10,000,000 it is only possible to show clearly the boundaries of drainage basins which have an area in excess of about 6000 sq · km. Nonetheless it does provide a first approximate attempt to depict one phase of sedimentation in Canadian rivers, an aspect of which is summarized in the following table:

Suspended sediment concentration (mg/l)	% of total land surface
0 - 50	59.2
51 - 200	21.5
201 - 400	11.9
401 - 700	5.9
701 - 1000	0.8
> 1000	0.7

Sediment load values have long been considered as indicators of the erosion activities on a watershed (Langbein and Schumm, 1958), even though there are many other environmental factors which may have influenced these processes in one way or another (Judson and Ritter, 1964). Consequently the map may be regarded as showing the results of the morphological processes performed by a unit of runoff on various watersheds of the country.

An approximation of sediment concentration for different rivers may be estimated from this map. For this purpose, the watershed area of the considered stream should be plotted on the map and the corresponding concentrations shown on the map for adjacent watersheds should be properly determined. The average concentration for the whole watershed may then be estimated using these determined values.

It is evident that all the territory of Canada from the point of view of sedimentation and erosion could be divided into regions but the lack of data prevents making such divisions. It is not difficult however to find, even from the analyses of the available information that there are four main factors affecting the erosion and sedimentation processes which form the separate regions:

(a) *Geological formation:*

The rivers on the prairies or in other regions which are similarly made up of sedimentary rocks with glacial drift have

high sediment concentrations. Such rivers include many streams in the Prairie Provinces, such as the South Saskatchewan, North Saskatchewan, Red, Athabasca, and Peace Rivers.

(b) *Slope of river channels or elevation of watersheds:*

It is not difficult to identify that the rivers in the mountain regions have more intensive erosion and also higher sediment concentration, particularly during the spring runoff periods. This is caused by high velocities in the streams and in some cases by the action of moving glaciers.

(c) *Climatological condition or geographical location:*

The results on the map also illustrate that the erosion processes and consequently the sediment concentrations in the southern regions are higher than those in the northern regions. Two main factors are stimulating to such distribution of erosion and concentration: there is more tillable land in the southern regions, and the runoff periods in the northern regions are much shorter.

(d) *Man's activities, reduction of forested areas, other developing activities:*

An important factor in the acceleration of erosion and the production of sediment in the streams is man's activities, particularly in the field of agriculture. Widespread use of land for the production of food started in eastern Canada in the 18th century, and since then, more land has been brought under cultivation. It is this increase in man's activities that has caused more disturbance to nature and, in turn, has resulted in more land erosion and more sediment in the streams. Ongley (1976) has pointed out that the "presence of significant quantities of particulate material is a recent phenomenon associated with the post-colonial period". The removal of forest cover and conversion of land into cultivated land can accelerate the process of erosion tremendously. In southern Ontario, for example, there has been a three-fold increase in sedimentation rates since the 1930's (Kemp, 1974) and modern sediment loads are probably 4 to 5 times greater than they would be if the area had remained undisturbed by man.

Although this map should be considered as qualitative rather than quantitative it can assist in showing very quickly if quality problems exist in a basin and if so, where. The likely cause of these problems can be inferred from such maps. It is also possible to visualize how one quality problem may influence another favourably or unfavourably. Although useful for general appraisal, such maps would not be used to formulate project concepts to solve quality problems because of the complexity of the problems and the many parameters involved.

Thus although such maps are only one input into the area of environmental mapping they are "absolutely necessary because water is vital to man's development of a balanced use of an area's natural resources" *(Hydrological Maps,* 1977).

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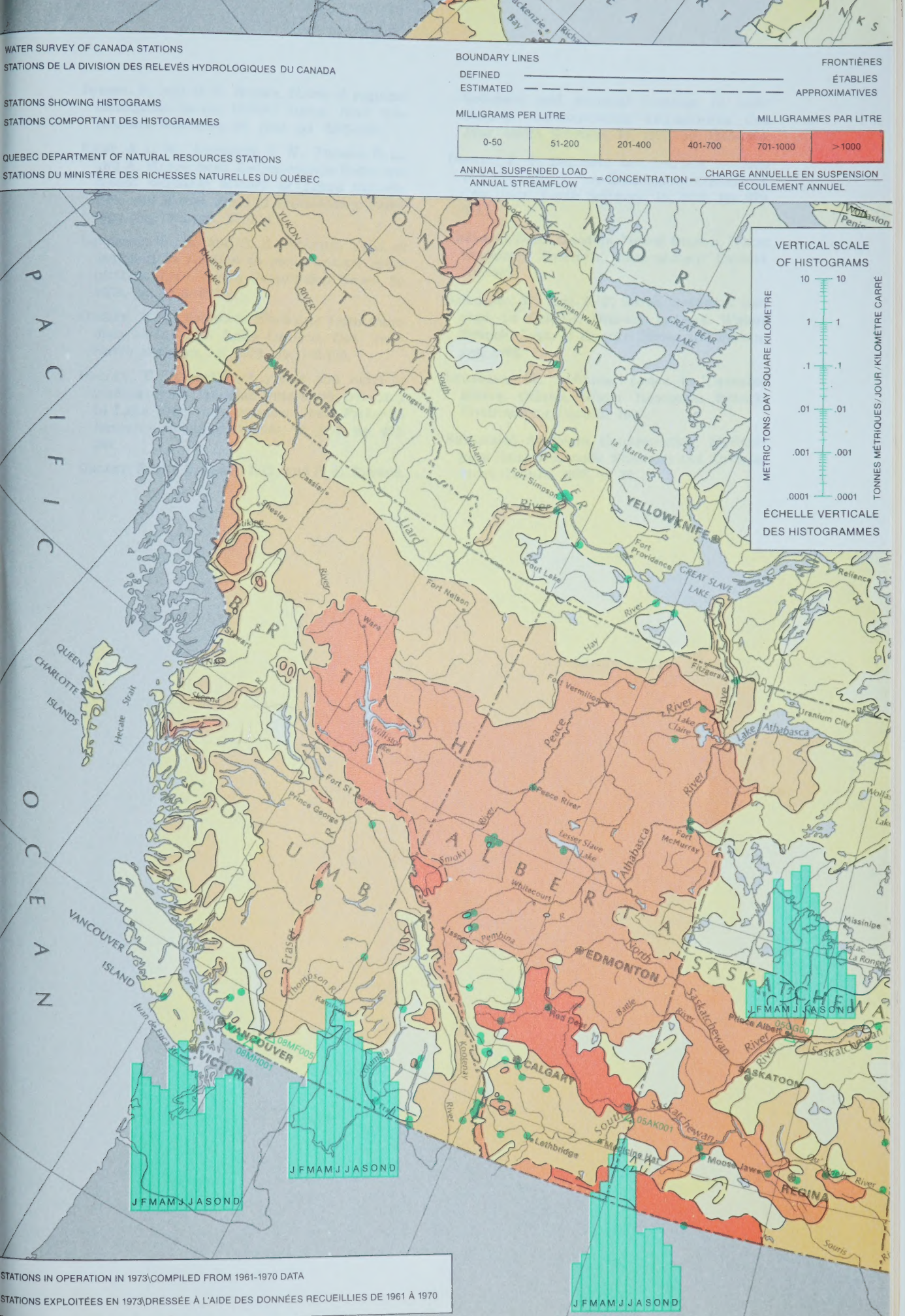
WATER SURVEY OF CANADA STATIONS
STATIONS DE LA DIVISION DES RELEVÉS HYDROLOGIQUES DU CANADA
STATIONS SHOWING HISTOGRAMS
STATIONS COMPORTANT DES HISTOGRAMMES
QUEBEC DEPARTMENT OF NATURAL RESOURCES STATIONS
STATIONS DU MINISTÈRE DES RICHESSES NATURELLES DU QUÉBEC
BOUNDARY LINES
DEFINED
ESTIMATED
FRONTIÈRES
ÉTABLIES
APPROXIMATIVES
MILLIGRAMS PER LITRE
MILLIGRAMMES PAR LITRE
0-50
51-200
201-400
401-700
701-1000
>1000
ANNUAL SUSPENDED LOAD / ANNUAL STREAMFLOW = CONCENTRATION = CHARGE ANNUELLE EN SUSPENSION / ÉCOULEMENT ANNUEL
VERTICAL SCALE OF HISTOGRAMS
METRIC TONS/DAY/SQUARE KILOMETRE
TONNES MÉTRIQUES/JOUR/KILOMÈTRE CARRÉ
10
1
.1
.01
.001
.0001
ÉCHELLE VERTICALE DES HISTOGRAMMES
PACIFIC OCEAN
YUKON TERRITORY
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
WHITEHORSE
YELLOWKNIFE
EDMONTON
CALGARY
SASKATOON
REGINA
VICTORIA
VANCOUVER
VANCOUVER ISLAND
QUEEN CHARLOTTE ISLANDS
GREAT BEAR LAKE
GREAT SLAVE LAKE
Lake Athabasca
Peace River
Fort Nelson
Liard River
Fort McMurray
Lesser Slave Lake
Athabasca River
Saskatchewan River
South Saskatchewan
Red Deer
Battle River
Lethbridge
Medicine Hat
Moose Jaw
Souris
Fraser
Thompson R.
Columbia
Kootenay
Yukon River
Mackenzie
Liard
Peace
Hay
Slave
Athabasca
Saskatchewan
Souris
08MF005
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STATIONS IN OPERATION IN 1973\COMPILED FROM 1961-1970 DATA
STATIONS EXPLOITÉES EN 1973\DRESSÉE À L'AIDE DES DONNÉES RECUEILLIES DE 1961 À 1970

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WATER QUALITY MAPS IN HUNGARY

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The ever-increasing volume of waste water flowing into the streams from the sewers of cities, and from industrial plants can no longer be processed by the rivers' natural system of self-purification. Growing pollution jeopardizes river ecology and renders it difficult to re-use water for irrigation, obtaining drinking water, etc., and sometimes even prevents it.

To prevent the continuous flow of waste waters into the rivers, and to take appropriate measures on the polluted river sections of industrial countries regular measurement of the rivers' water quailty linked to cartographic representation of measurement data are made necessary.

In Hungary regular collection of data on the quality of surface water has been performed since 1965, and two types of surface quality maps have been published each year.

Distance of sample sites from each other and frequency of sampling depends on the size of the stream. Distance of sample sites from each other is 10-15 km on bigger rivers and sampling is done weekly, while on smaller streams they are 20-30 km apart and sampling frequency is 30 days.

Of the two maps of scale 1 : 1,400,000 one is based on the water quality classification adopted by the Council for Mutual Economic Assistance, while the other represents the quality of surface waters on the basis of stricter Hungarian water quality directives.

I. QUALITY OF SURFACE WATERS BASED ON THE CMEA DIRECTIVES

By the early 1960s it became evident that the data of oxygen balance alone, e. g. oxygen consumption, content of dissolved oxygen, degree of oxygen saturation, are insufficient to judge the quality of waters. Fertilizers, cleaning compounds, especially high-action detergents, even in small quantities could make water unsuitable for re-use (e. g. drinking water supply) —waters that are otherwise classifield as "clear" on the basis of oxygen balance indices.

Therefore three linear symbols —three colour bands— are printed on all streams on maps compiled according to the CMEA directives. The bands are divided by thin white strips. The individual bands mark the pollution of waters by the different character —groups, i. e. data of oxygen balance, mineral content, chemical compounds that are harmful even in small quantities. Depending on the degree of pollution four categories were set up in all three groups. Dark blue stands for clear water, yellow and red show pollution of different degrees, while the strongly polluted waters totally unsuited for re-use are indicated by the colour brown.

For all groups, category limits are set with regard to water use needs, to water

pollution and to the possibilities of quality improvenent. The least favourable values —comprising about 25 % of all data— are chosen from the yearly figures and their arithmetic mean is computed. The value thus obtained is compared to the category limits, and streams are represented accordingly on the map.

The corresponding bands to the individual character groups (index-groups) were set along the streams in the following manner: taking the direction of flow, the left band stands for the oxygen balance, the right band for the chemical compounds harmful even in small quantities, while the quality classification of the middle band is based on the indices of mineral content. In the case of lakes (e. g. L. Balaton) the inner band marks the data of oxygen balance, while the outer shows that of polluting materials harmful even in small quantities.

II. QUALITY CLASSIFICATION OF SURFACE WATERS BASED ON THE HUNGARIAN DIRECTIVES

Hungarian indices define the quality of waters from the viewpoint of water use. Because the rate of flow strongly influences the water quality of a stream with a given degree of pollution, the map shows the rivers with bands of varying width proportionate to their rate of flow. Depending on the nature of the use, e. g. for drinking water, industrial water, irrigation, fisheries, requirements for the clarity of surface waters vary. These varying demands are indicated on the map by different symbols. Colour fillings of bands standing for the rivers demostrate their pollution from the viewpoint of drinking water supply. Hatches of different directions show water quality from the viewpoint of industrial use, dotted lines or broken lines drawn on the axis of the band indicate quality from the irrigational standpoint. Quality of water used by fisheries is shown by saw-tooth-like drawings on the left side of the band having regard to the direction of flow.

Classification of surface waters is being carried out on the basis of general and special indices. General indices corresponding to the water usage ase as follows:

With communal water supply:

— consumption of oxygen,
— degree of oxigen saturation,
— pH,
— cyanide (CN-),
— ether extract,
— phenols,
— detergents (anion active).

With industrial water supply:

— pH,
— all hardness,
— all dissolved materials,
— ether extract.

With agricultural water supply:

a) Irrigation:

— pH,
— all dissolved material,
— sodium %.

b) Fisheries:

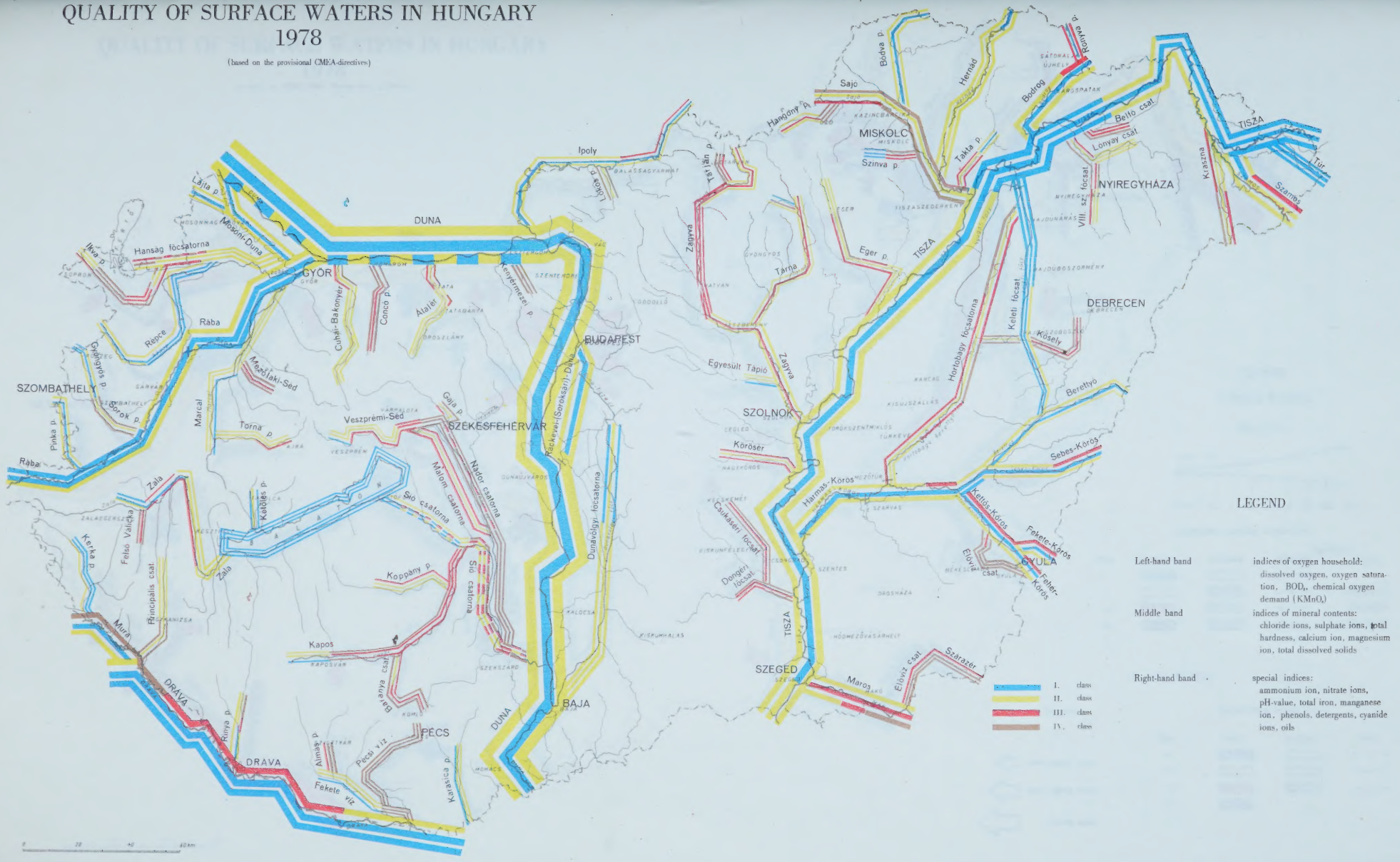
— degree of oxygen saturation,
— ammonium (NH_4 +),
— sulphide (S^{2} —),
— ether extract,
— phenols,
— biological state.

Apart from these general indices, it may happen that a specific compound, e. g. oil occurs in the area and to such a degree that determines the class of water quality, regardless of water usage. Under these circumstances a special index is used and classification of water has to be carried out accordingly, pointing out specifically the index on which the classification is based.

Larger quantities of waste water dis-

QUALITY OF SURFACE WATERS IN HUNGARY
1978

(based on the provisional CMEA-directives)



LEGEND

Left-hand band	indices of oxygen household: dissolved oxygen, oxygen saturation, BOD_5, chemical oxygen demand ($KMnO_4$)
Middle band	indices of mineral contents: chloride ions, sulphate ions, total hardness, calcium ion, magnesium ion, total dissolved solids
Right-hand band	special indices: ammonium ion, nitrate ions, pH-value, total iron, manganese ion, phenols, detergents, cyanide ions, oils

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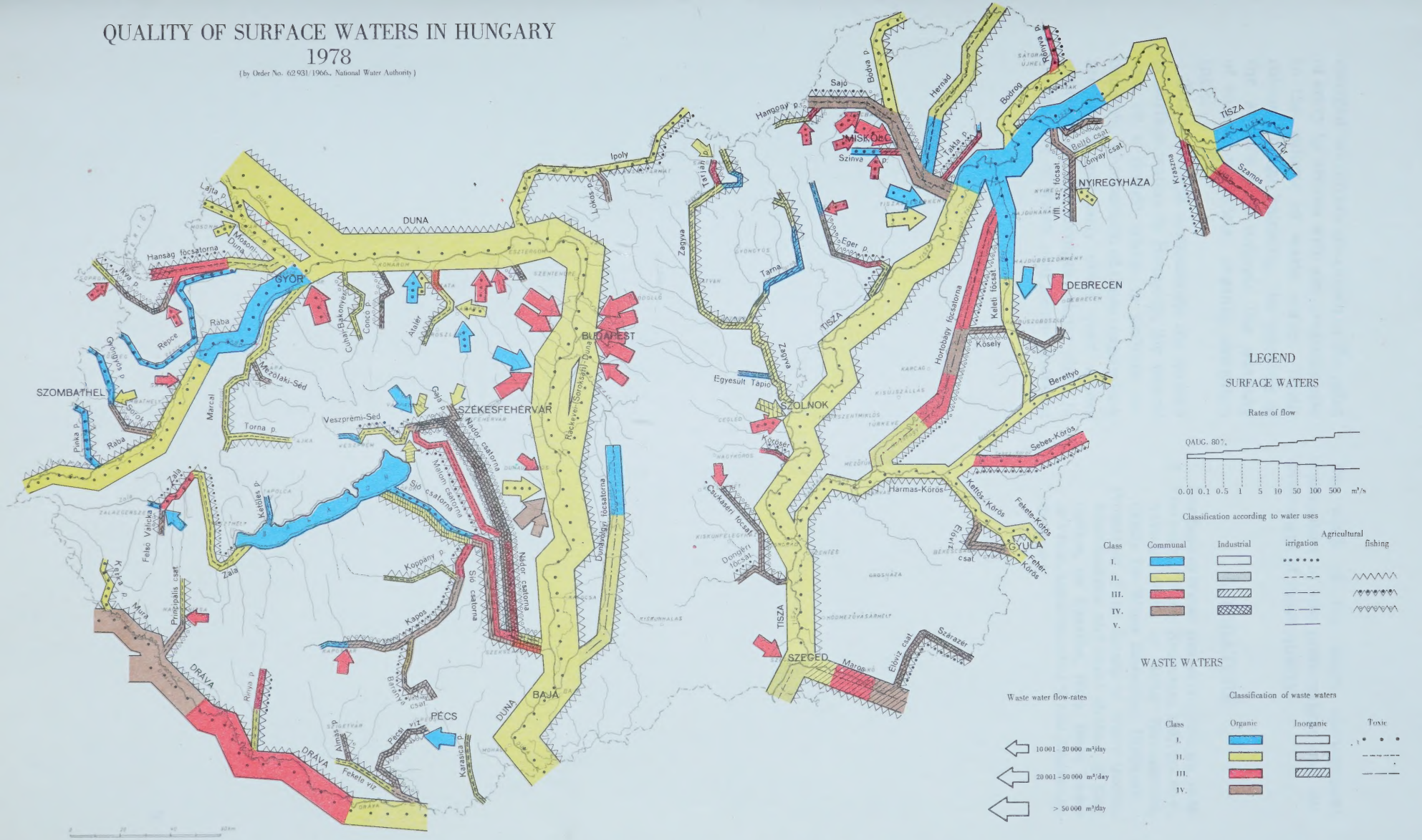
QUALITY OF SURFACE WATERS IN HUNGARY
1978

(by Order No. 62 931/1966., National Water Authority)



LEGEND

SURFACE WATERS

Rates of flow

Classification according to water uses

Class	Communal	Industrial	Agricultural irrigation	Agricultural fishing
I.				
II.				
III.				
IV.				
V.				

WASTE WATERS

Waste water flow-rates

- 10 001 – 20 000 m³/day
- 20 001 – 50 000 m³/day
- > 50 000 m³/day

Classification of waste waters

Class	Organic	Inorganic	Toxic
I.			
II.			
III.			
IV.			

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charged into rivers are shown at the point of entry by arrows with size proportionate to the volume of waste water. Their colour fillings hatching, the drawing of the arrow's axis indicate the quantity of various materials: organic, inorganic, toxic.

The two maps demonstrate the quality of surface waters in Hungary, the second one by a design which is perhaps too complex. Comparison of these maps which are issued regularly every year, shows expressively the changes taking place in the quality of water, and hence promotes the work of the water management authorities in the preservation and improvement of water quality.

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LA CARTOGRAPHIE PAR MAILLE DE L'INVENTAIRE FORESTIER NATIONAL EN FRANCE

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Le Service de l'Inventaire Forestier National (I. F. N.), dépendant du Ministère de l'Agriculture, a pour mission de procéder à l'inventaire permanent des ressources forestières de la France. L'unité géographique de travail est le département (95 en France métropolitaine). La cadence prévue est de dix ans.

L'inventaire est fait au moyen d'un échantillonnage systématique sur photos aériennes au moyen de points (1 point pour 30 - 40 ha, environ) qui y sont étudiés par rapport à diverses caractéristiques (usage, propriétés, site, et, pour ceux tombant en forêt, type de peuplement et caractéristiques volumétriques). Les points sont en général déterminés par une grille de points appliquée sur les photos. A noter que, du fait des photos et des irrégularités des plans de vol, le semis de points obtenu sur le département n'est pas régulier; de plus, les points ne sont pas immédiatement repérés géographiquement en x, y.

Parmi ces points de 1ère phase, préalablement stratifiés, on tire au hasard un certain nombre de points, qui constituent l'échantillon de seconde phase. Ces points sont visités au sol. On y installe des placettes circulaires sur lesquelles sont levés tous les arbres existants. Ces mesures permettront de donner les résultats quantitatifs (surfaces, volumes, accroissement, nombre d'arbres) de l'inventaire.

Ces données, tant de première que de seconde phase, sont stockées sur fichier magnétique, à partir duquel on peut faire toutes les études statistiques que l'on veut.

L'I. F. N. a cherché à utiliser aussi le fichier de 1ère phase à des fins cartographiques, si possible automatisées. Pour cela, il a été amené, dans les départements devant faire l'objet de la cartographie par maille exposée ci-après, à déterminer les points 1ère phase sur carte suivant un maillage régulier (1 maille = 500 m × × 625 m = 31,25 ha) calé sur les coordonnées Lambert, puis à les reporter sur photos. Sont ainsi éliminés les inconvénients signalés plus haut. L'I. F. N. peut alors sortir des cartes d'étude sur listage (à chaque maille est affecté un caractère traduisant les données).

LA CARTOGRAPHIE

Il était normal de chercher aussi à automatiser au maximum l'édition de la cartographie envisagée. Ce travail de recherche a été mené en collaboration étroite entre l'I. F. N. et l'Institut Géographique National.

Le processus adopté, mis en oeuvre par l'I. G. N. est le suivant:

— échelle: 1:250 000;
— à chaque type de peuplement sont

affectées les composantes colorées de la couleur qui le représentera;
— on procède sur table traçante à l'évidement par gravure des différentes planches intermédiaires (remplace le pelliculage manuel);
— on procède aux combinés photographiques habituels pour obtenir les planches-mères de Cyan, Magenta, Jaune et Noir.

L'énorme avantage de ce processus est sa simplicité et sa sûreté.

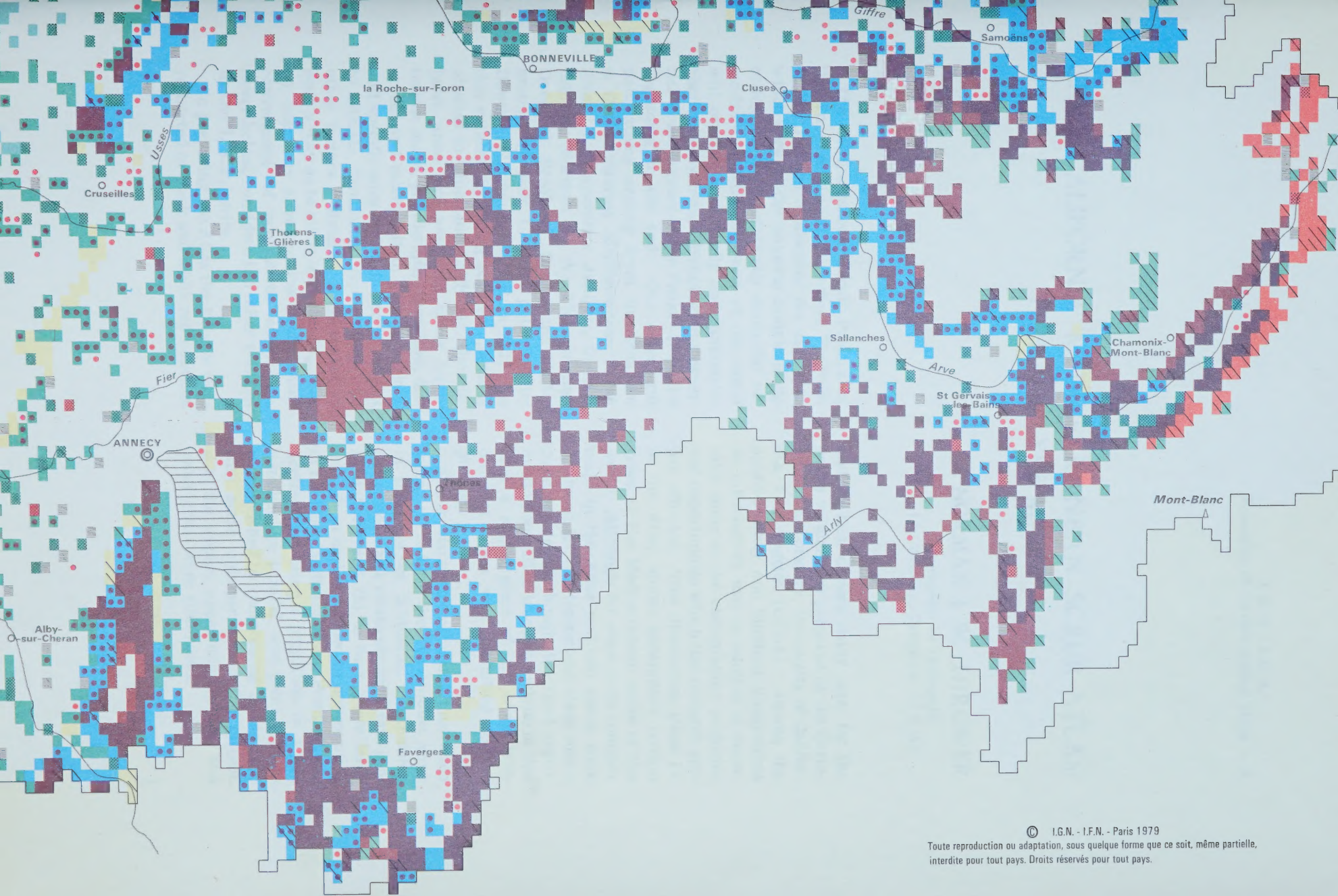
Sémiologiquement parlant, on a cherché la meilleure logique visuelle:

— les résineux se partagent la gamme des violets;
— les feuillus se répartissent dans les verts, bleus, jaunes;
— les plantations sont symbolisées par des surcharges particulières (gros points alignés);
— les terrains agricoles ou improductifs sont purement et simplement laissés en blanc;
— le fond de carte est volontairement très schématisé.

LES PERSPECTIVES

Aujourd'hui seule la Savoie est déjà imprimée. La Haute-Savoie et le Puy-de-Dôme sont en cours de réalisation. D'autres départements sont en préparation.

L'ensemble des départements, s'ils sont tous ainsi cartographiés, constituera l'atlas de la France.



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CHILE-CALIFORNIA MEDITERRANEAN SCRUB ATLAS: TERRAIN TYPE MAP

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The Mediterranean Scrub Project of the International Biological Program (I. B. P.) aimed to discover the degree to which very similar physical environments acting on phytogenetically dissimilar organisms in different parts of the world will produce structurally and funtionally similar ecosystems. Mapping was essential to the success of the Project from the beginning to the end. One of several publications arising from the Program is *Chile-California Mediterranean Scrub Atlas: A Comparative Analysis,* General Editors, Norman J. W. Thrower and David E. Bradbury, Design and Cartography by Noel L. Diaz, published by Dowden, Hutchinson and Ross, 1977. In this volume, by facing page comparisons of sites in Chile and California, the disjunct areas are presented using large-format maps, photographs, drawings, diagrams and tables. Both general regions and specific sites are examined in respect to climate, landforms, flora, fauna and other factors. Material is presented in such a way as to allow individual opinion on questions affecting the evolutionary convergence of ecosystems which are, nevertheless, considered in other volumes in the I. B. P. series.

In preparing the *Atlas* the Editors were restricted to black and white reproduction and, in fact, camera ready copy for the entire volume was prepared at the Cartography Laboratory, University of California, Los Angeles (UCLA). Among the approximately one hundred illustrations an introductory map is selected to exemplify some of the cartographic problems and opportunities which this research project afforded. This illustration, Plate IV in the *Atlas,* shows generalized terrain types of the Mediterranean areas of the world. Although for some more complex maps in the *Atlas* multiple plates were produced for half-toning and other manipulations (even though the final reproduction was all in black and white) in this case a single piece of art work with different tones was submitted to the printer.

The special problems in this illustration were: (a) to have the five disjunct areas in their correct latitudinal relationship (longitude was a relatively important consideration), and (b) to have them large enough in scale to allow an appreciation of the basic landform types. Point (a) was achieved by using a projection in which parallels are parallel, and point (b) was accomplished by compressing the units so that areas unimportant to the project, e. g. the tropics, upper mid-latitudes and polar areas were eliminated.

A simple four-fold classification of the terrain types is used. On this basis it can be clearly seen that Chile and California are the two units most similar in this particular distribution. This was a first order approximation for the more and more detailed considerations which followed covering all major aspects of the physical and bio-geography of Chile and California —soils, plants, animals, etc. A selected list of the U. S./I. B. P. volumes is appended below.

Baker, P. T., and M. A. Little (1976): *Man in the Andes: a Multidisciplinary Study of High-Altitude Quechua.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 6.

Blair, W. F. (1977): *Big Biology.* The U. S./I. B. P. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 7.

Mabry, T. J.; J. M. Hunziker, and D. R. DiFeo (1977): *Creosote Bush: Biology and Chemistry of "Larrea" in New World Deserts.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 6.

Mooney, H. A. (1977): *Convergent Evolution in Chile and California: Mediterranean Climate Ecosystems.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 5.

Orians, T. H., and O. T. Solbrig (1977): *Convergent Evolution in Warm Deserts.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 3.

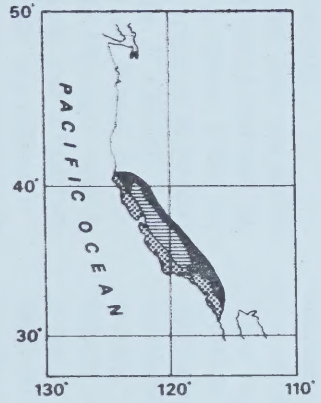
Simpson, B. B. (1977): *Mesquite: Its Biology in Two Desert Ecosystems.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 4.

Thrower, N. J. W., and D. S. Bradbury (1977): *Chile-California Mediterranean Scrub Atlas: A Comparative Analysis.* Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania U. S./I. B. P. Synthesis Series, Vol. 2.

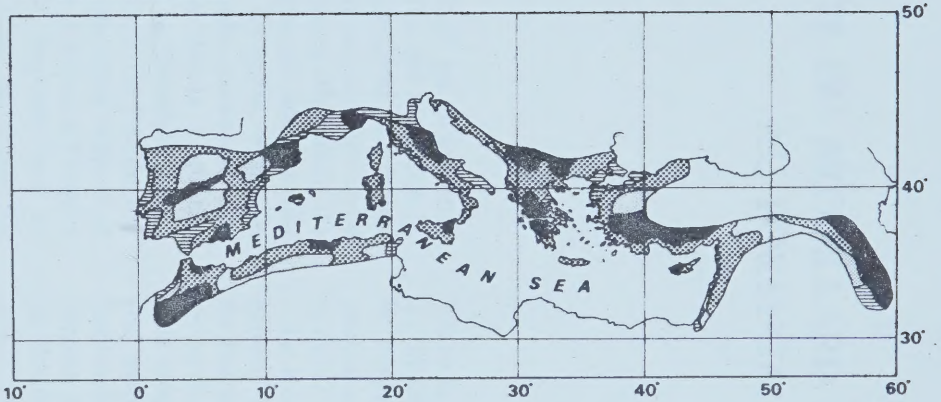
GENERAL TERRAIN TYPES

Mountains
Low mountains and hills
Tablelands or rough plains
Plains

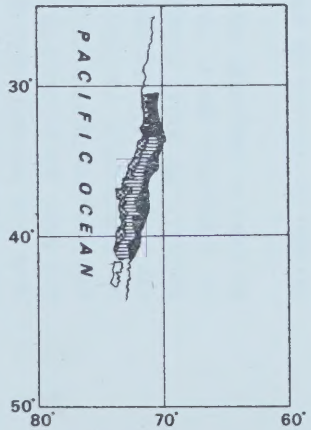
CALIFORNIA



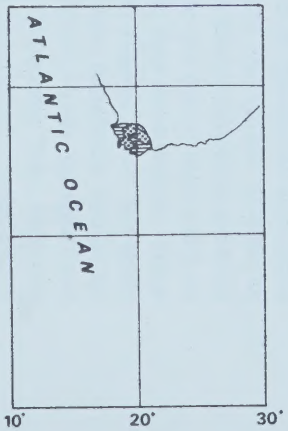
THE MEDITERRANEAN



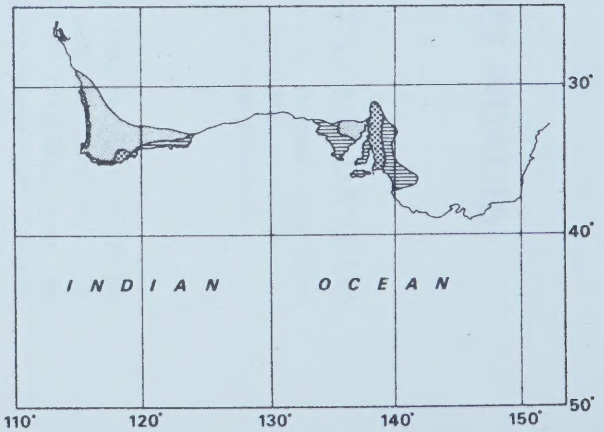
CENTRAL CHILE

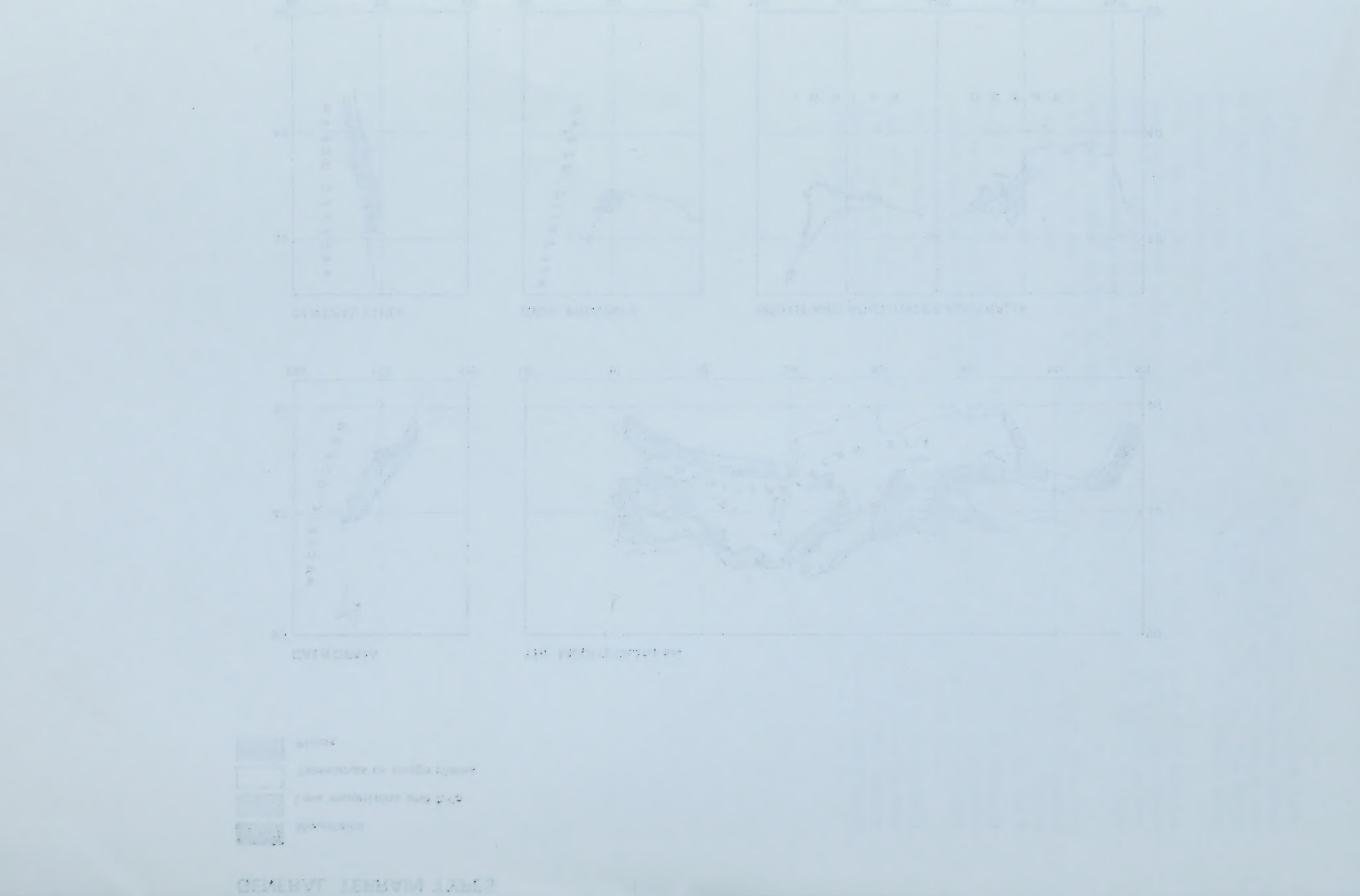


CAPE PROVINCE



SOUTH AND SOUTHWEST AUSTRALIA





UNE CARTE DU BROUILLARD ET DES NUAGES AU PORTUGAL

SUZANNE DAVEAU
Centro de Estudos Geográficos
Faculdade de Letras
Lisboa (Portugal)

La carte dont un extrait est ici présenté est dérivée de celle qui a été réalisée à la demande de la *Direcção-Geral do Planeamento Urbanístico,* qui est un Service de Planification du Territoire dépendant du Ministère de l'Habitation et des Travaux Publics du Portugal. La carte originelle s'insère dans une étude consacrée aux "Caractères climatiques locaux à prendre en considération pour la Planification du Territoire". Les résultats de l'étude ont été fournis sous la forme d'un rapport et de deux cartes en noir et blanc, à l'échelle de 1 : 250.000 (échelle imposée lors de la commande), dont l'une est consacrée aux Contrastes Thermiques et l'autre au Brouillard et à la Nébulosité.

Ce travail a été réalisé sous ma direction par un groupe de collaborateurs du *Centro de Estudos Geográficos,* aidés par des étudiants en Géographie de la Faculté des Lettres de Lisbonne. Il s'inscrit dans le cadre des activités du Projet de Recherche en Géographie Physique que je dirige et qui est financé par l'*Instituto Nacional de Investigação Científica.*

Les résultats scientifiques complets de la recherche sont en cours de rédaction et feront l'objet d'une publication dans la collection de *Memórias* du Centre d'Etudes Géographiques. La carte des Contrastes Thermiques sera publiée en couleurs au 1 : 500.000 et la carte du Brouillard et de la Nébulosité au 1 : 1.000.000, avec les couleurs qui apparaissent sur l'extrait ci-joint.

Le brouillard et la nébulosité sont deux aspects importants du climat atlantique du Portugal. Une planification rationnelle du territoire exige que soient bien connues leur fréquence et leur localisation. Selon les activités envisagées, leur présence habituelle peut être bénéfique (certaines formes d'agriculture ou de sylviculture) ou franchement répulsive (cultures exigeant une forte insolation, implantation de routes, d'aéroports, construction d'habitations, de lieux de travail, de centres touristiques...).

Par rapport à leur interférence avec les activités humaines, il est important de distinguer les divers types de rythmes journalier et annuel des brouillards et des nuages. Les brouillards d'advection du littoral occidental se manifestent surtout le matin pendant la saison d'été, alors que les brouillards de rayonnement sont particulièrement abondants au creux des dépressions topographiques pendant les nuits d'hiver. Quant aux nuages qui s'accrochent longuement à certains versants, ils sont naturellement surtout fré-

quents pendant la période pluvieuse de saison fraîche dont la durée s'accroît fortement du Sud au Nord du Portugal.

La documentation de base qui a servi à établir la carte est constituée par les observations des stations climatologiques, effectuées et publiées par le *Serviço Meteorológico Nacional* du Portugal (récemment transformé en *Instituto Nacional de Meteorologia e Geofísica).* Les publications de cet organisme sont d'excellente qualité, en raison de la continuité, de l'homogénéité et de la densité en général élevée de l'information fournie.

On disposait des informations suivantes:

— Le nombre mensuel et annuel de jours de *brouillard,* auquel pouvait s'ajouter dans certains cas, pour confirmation, le nombre de jours de rosée et de gelée blanche.

— Les données concernant la *nébulosité* (observations à 9^h, 15^h et 18^h en principe, nombre de jours avec nébulosité $\geqq 8/10$ et $\leqq 2/10$), auxquelles pouvaient s'ajouter, dans le cas des montagnes, les données concernant le brouillard.

— Le nombre de jours recevant une hauteur de *précipitation* comprise entre 0,1 mm et 1 mm, bon indicateur de la stagnation de brouillards ou de stratus accrochés aux versants.

— Le nombre d'heures et le pourcentage d'*insolation.*

Cependant quelques régions ou types de relief sont insuffisamment représentés dans le réseau de stations du Service Météorologique et, surtout, les observations concernant le brouillard et la nébulosité ne peuvent échapper à une certaine subjectivité qui résulte du caractère local et parfois fugace de leur manifestation. Quand une station enregistre du brouillard, est-ce à dire que les instruments étaient plongés dans celui-ci? qu'il apparaissait à quelque distance, plus haut ou plus bas sur le versant? qu'il se manifestait à l'heure même de l'observation ou qu'il venait de disparaître?...

Il est d'autant plus difficile de comparer entre eux les résultats enregistrés dans les diverses stations que la localisation de celles-ci n'est fournie qu'avec une approximation de une minute de longitude et latitude (quand elle n'est pas franchement fausse, comme il arrive malheureusement souvent). Une connaissance exacte du site où ont lieu les observations serait pourtant fondamentale quand il s'agit d'aspects du climat qui sont sous l'étroite dépendance des facteurs topographiques.

Les enregistrements sont donc parfaitement utilisables du point de vue qualitatif (puisqu'ils fournissent une bonne information sur le rythme annuel et, en partie, sur le rythme journalier des manifestations). Mais ils permettent difficilement des comparaisons quantitatives. Comme, d'autre part, la finalité de la carte implique surtout une utilisation à niveau régional et local (et non national), on a décidé de réaliser une *représentation qualitative, faisant ressortir les contrastes locaux, mais sans aucune prétention à l'homogénéité quantitative à l'échelle nationale.*

Il s'agit là d'une limitation importante du document proposé et dont il est indispensable que l'utilisateur soit parfaitement conscient. Un versant dit nébuleux en Algarve (Sud du Portugal) peut présenter une insolation supérieure à un versant dit non nébuleux dans le Nord-Ouest pluvieux du pays. De même, un bas-fond à brouillard des régions intérieures proches de la frontière espagnole peut connaître plus de nuits limpides que certains versants ou interfluves des régions de transition atlantiques où la fréquence des brouillards nocturnes et matinaux est particulièrement élevée. On est parti du principe que ce sont surtout les contrastes locaux qu'il importe de connaître pour choisir le site d'implantation des réalisations projetées, ce qui justifie la réalisation d'une carte où un même signe n'a pas partout le même *poids* quantitatif.

L'unique type de brouillard pour lequel on a introduit une subdivision quantitative est le brouillard d'advection du littoral occidental. Encore s'agit-il d'une distinction non numérisée et davantage basée sur l'expérience vécue au long du littoral par les collaborateurs de la carte que sur l'exploitation directe des données

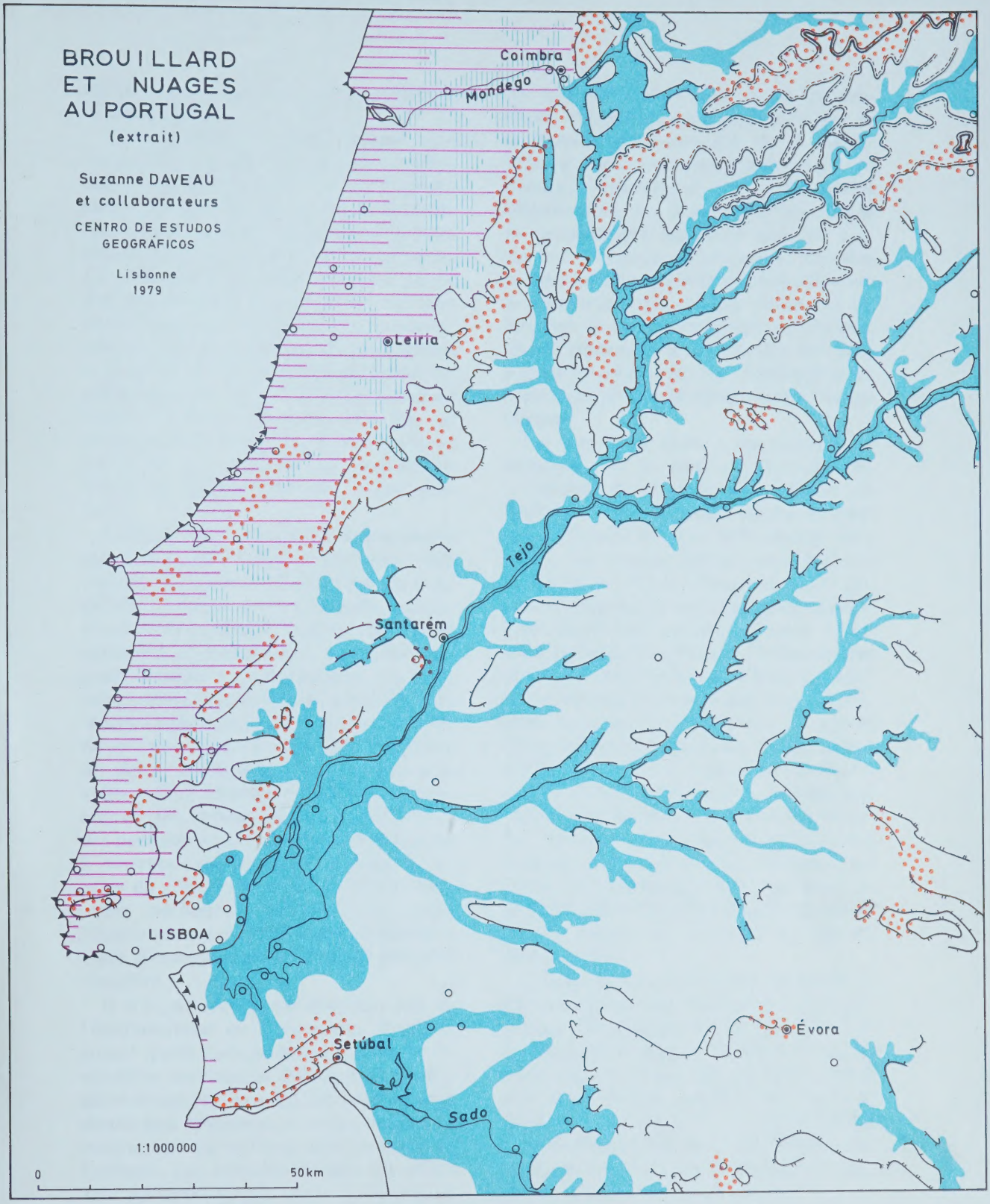
BROUILLARD ET NUAGES AU PORTUGAL

(extrait)

Suzanne DAVEAU
et collaborateurs

CENTRO DE ESTUDOS GEOGRÁFICOS

Lisbonne
1979



Formes du relief		
Altitudes	Collines et montagnes	Vallées encaissées
< 400 m		
400-700 m		
700-1200 m		
> 1200 m		
Littoral	côte basse falaise vive falaise morte	
Lieux d'observation	○	

Type	Caractères	Rythme annuel	Rythme journalier
Brouillard littoral (d'advection) très fréquent / fréquent	Brouillard ou bas stratus	Été	le matin mais persistant parfois toute la journée
Brouillard des bas-fonds situés loin de la mer (d'irradiation)	pellicule de brouillard	Automne Hiver Printemps	la nuit et au début de la matinée
Brouillard des bas-fonds situés près de la mer (mixtes)	mixtes	toute l'année	le matin
Versants nuageux	journées nébuleuses fréquentes avec ou sans pluie	Variable en fonction de la situation géographique	

numériques enregistrées par les stations climatologiques.

L'*interpolation* a obligatoirement joué un grand rôle dans le dessin de la carte. Elle a été facilitée par le fait que le brouillard et les nuages sont des aspects climatiques dont la localisation est sous l'étroite dépendance des formes topographiques. La généralisation a été réalisée à partir des enregistrements dont le site est bien connu (parfois en fonction de la description fournie par le Service Météorologique, le plus souvent comme résultat d'une enquête locale) et à partir de la connaissance directe de divers lieux du pays que les collaborateurs du projet et les personnes qu'ils ont pu consulter ont acquise au cours de séjours plus ou moins prolongés.

La carte actuelle ne doit être considérée que comme une ébauche provisoire, déjà capable de rendre de grands services, puisqu'elle visualise toute une série de contrastes locaux dont la majeure partie des personnes responsables de décisions engageant l'avenir de l'organisation du territoire n'avaient aucune idée avant de l'observer. Mais cette carte sera susceptible de sérieuses améliorations par l'utilisation de deux techniques d'information nouvelles. Tout d'abord l'enquête directe auprès des populations, et en particulier des personnes que leurs activités amènent à observer avec attention les nuances locales du climat (paysans, pasteurs, chasseurs, pêcheurs, camionneurs, etc.). D'autre part, par l'interprétation systématique d'enregistrements réalisés par télédétection.

Il n'a pas encore été possible, lors de l'établissement de cette carte, d'utiliser autant qu'on l'aurait désiré les *images de satellites* couvrant le Portugal. Les enregistrements par les satellites Landsat sont encore peu nombreux et moins nombreux encore ceux qui existent effectivement au Portugal. Les enregistrements des satellites météorologiques dont la définition est suffisante nous sont restés inaccessibles. Cependant les images Landsat de la journée anticyclonique du 2 février 1975, qui couvrent une grande partie du Portugal, constituent une confirmation réconfortante du dessin des brouillards de rayonnement matinaux dans les basfonds des régions continentales. D'autres images suggèrent d'intéressantes idées sur la répartition des nappes nuageuses en fonction du relief. Nul doute qu'une prochaine édition de la carte puisse être sensiblement améliorée par l'interprétation systématique des enregistrements par satellites.

Le fond de la carte a été extrait, par réduction, de la carte du Portugal au 1 : 250.000 du *Serviço Cartográfico do Exército*. Outre quelques points de référence (fleuves et villes principales), on a établi une représentation des accidents du relief, en faisant ressortir ceux qui, par leur vigueur et leur continuité, paraissent exercer une sensible influence climatique (massifs de collines et de montagnes et vallées encaissées). Le dessin du relief a été très simplifié et allégé, afin d'interférer le moins possible avec les signes climatiques qui constituent le sujet même de la carte. On a cependant distingué quatre classes altitudinales, limitées par les valeurs de 400, 700 et 1.200 mètres, qui correspondent aux modifications sensibles du paysage au Portugal. La classe retenue signifie que l'essentiel de la forme représentée lui appartient, même si son sommet ou son fond la dépasse quelque peu.

L'ensemble des études qui ont abouti à l'établissement des deux cartes des Contrastes Thermiques et du Brouillard et des Nuages se sont déroulées au long de deux années, l'essentiel du travail étant cependant réalisé pendant les vacances d'été, bien qu'une activité réduite ait pu être maintenue au cours de l'année scolaire par les étudiants et enseignants qui ont participé à leur élaboration.

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